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## Memory Defects in the Organic Psychoses

An Experimental Study

BY

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JOHAN LILJENCRANTS, S.T.D., PH.D.

Washington, D. C.

(From the Psychological Laboratory of St. Elizabeth's Hospital,  
Washington, D. C.)

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## INTRODUCTION

It is a well known fact that more or less marked memory defects appear in the organic psychoses. In general paresis the incipient symptoms include memory defects which in subsequent stages develop into utter failure of memory. There is loss of memory in senile dementia and in arterio-sclerosis, as also in Korsakow's psychosis. The memory is noticeably affected in alcoholic dementia and in other toxic psychoses, in the psychoses associated with cerebral syphilis and apoplexy, in epileptic dementia, myxoedema, and so forth. Subjects will be found who are unable to remember practically the whole of their past life. Others, while retaining memory of the more remote past, have lost totally or almost totally the memory of the more immediate past, usually of the period introduced by the advent of their brain disease or lesion. Some thus afflicted remember certain events, they know their name and age and are oriented in regard to time, place, and persons surrounding them, while others show a more or less profound ignorance even of these things.

It is possible, then, to give a fairly accurate clinical description of the memory defects associated with organic psychoses by classifying them as circumscribed or general, retrograde or anterograde amnesias.<sup>1</sup>

Knowledge of the more intimate nature of these memory defects may be hoped for only through experimental investigation. The quantity of work done to date in this field has been very meager. In 1913 Boring published a monograph on *Learning in Dementia Praecox*.<sup>2</sup> His experiments included tests of attention, tests of memory span with digits presented both orally and visually, the Heilbronner apperception test, kinaesthetic memory tests, cancellation and maze tests. His primary object was to establish the subjects' facility for learning. Hart and Spearman published an account of *Mental Tests of Dementia* in 1915.<sup>3</sup>

<sup>1</sup> White, William A. *Outline of Psychiatry*, 1919, p. 78.

<sup>2</sup> *Psychol. Monog.*, June, 1913, Vol. XV.

<sup>3</sup> *J. Abnor. Psychol.*, 1914-15, Vol. IX, pp. 217 et seq.

They employed the method of paired associations and cancellation tests. In a study of the correlation between memory and perception Moore experimented on a number of inmates of asylums suffering from paresis, senile dementia, Korsakow's psychosis, chronic alcoholism and paralysis.<sup>4</sup> He found a general tendency for both memory and perception to deteriorate together, although in some cases one of these functions was affected without the other. In 1920 Dr. Achilles published a monograph on *Experimental Studies in Recall and Recognition* containing a chapter on memory tests of insane patients.<sup>5</sup> The subjects represented the Korsakow psychosis, general paralysis, arterio-sclerosis, senile dementia, cerebral syphilis, and undifferentiated psychoses. The general results of this study are that "there is little difference in recall among the patients suffering from general paralysis and arterio-sclerosis. In recognition, there is no difference except in the case of words for which the arterio-sclerosis patients score higher. (Omitting one patient who was recovering) one finds the scores among the Korsakoffs lower than those among the general paralysis and arterio-sclerosis cases. These patients were less able to attempt the tasks. There is no striking difference between the way the diseases affect recall and recognition."<sup>6</sup>

The psychological problems in the memory defects associated with organic psychoses are complex. Memory depends upon two factors, apprehension and retention. Moreover, as Kennedy and others point out, there are two "phenomena" of memory, recognition and reproduction. We distinguish memory according to the sense organs involved, thus we speak of visual, auditory, and kinaesthetic memory. A further distinction is made between immediate and mediate memory. The span of memory, or the number of items which can be remembered, enters as a factor in connection with apprehension and retention. Three general condi-

<sup>4</sup> Moore, Thomas Vernon, *The Correlation between Memory and Perception in the Presence of Diffuse Cortical Degeneration*. *Psychol. Monog.*, 1919, No. 120.

<sup>5</sup> *Archives of Psychol.*, 1920, No. 44.

<sup>6</sup> *Op. cit.*, p. 64.

tions influence the memory of past experiences, recency, vividness, and frequency. That of recency partly relates to the factor of retention, partly to the order or place in which an item is presented in a series. Vividness implies more than mere intensity of the stimulus, it is also concerned with the mental attitude of the subject. Frequency is measured in the number of times a stimulus is repeated. These various factors, "phenomena," kinds of memory, and conditions must be considered separately to determine more exactly the nature of memory defects.

The present investigation was confined to anterograde amnesia, or the inability of the subject to store up memories. Moreover, it was limited chiefly to visual memory; nevertheless a certain measure of comparison was provided by employing on the one hand material for visual together with auditory and kinaesthetic memory, and on the other material for only visual and kinaesthetic memory. The two kinds of material also provided for the distinction between immediate and mediate memory. Reproduction was limited to the method of verbal recall.

The questions which the present investigation has aimed to answer may be summarized as follows. Is the amnesia due to faulty apprehension, faulty retention, or to both? To what degree does the defect affect recognition and reproduction respectively? What is the relation of the defect to different kinds of visual stimuli? Does the defect affect the span of memory? What is the influence of primacy and recency, vividness, and frequency respectively on the memory of the defective? Does the memory defect manifest itself similarly in different individuals? How does the memory of the defective compare with that of "normal" individuals?

## I. PRELIMINARY EXPERIMENTS

The material used in the preliminary experiments consisted of half-tone pictures and of irregular figures, mounted on cards  $3\frac{1}{2}'' \times 4''$  and arranged in pairs so that the two cards of a pair were similar without being alike. Three, five, or more cards of different pairs were presented in succession, about one second each, with intervals of about two seconds, and the subject selected those he had seen from a simultaneous exposure of the shown cards with the remaining cards of the same pairs. Further description of material and method will be found in the section on method (pp. 8 *et seq.*). Three subjects, McG, E-n, and H-n were employed.

### I. SPAN OF MEMORY

A number of tests were made to find the approximate number of cards to the set which could be recognized immediately after presentation with a proportion of error suitable for experimental purposes.

*Experiments with Pictures.* McG obtained better results with 5 than with 3 cards to the set, 20 tests with 5-card sets giving 66 R., 1 H. R., 3 H. W., 3 W., and 2 N. from 75 T.<sup>1</sup> In the first five the results were lower than in the remaining tests, due doubtlessly to the subject's lack of familiarity with the experiment.

E-n obtained better results with 3 than with 5 cards to the set, 16 tests with 3-card sets giving 81 per cent R. and 10 tests with 5-card sets 66 per cent R. In the latter tests the score was 33 R., 2 H.R., 2 H.W., 3 W., and 10 N. from 50 T.

H-n. Tests with 5-card sets resulted in only right selections. In 10 tests with 10-card sets the score was 92 R., 2 H.W., 4 W., and 2 N. from 100 T.

<sup>1</sup> The letters, to be used in subsequent tables, signify:—R. right, W. wrong, N. no selection; H.R. right after hesitation, H.W. wrong after hesitation; T. total number of cards exposed.



*Experiments with Figures.* The figures consisted of four kinds of material, black irregular and colored irregular figures, straight lines, and ink blots. Each kind formed a separate series.

*McG.* Results with 3-card sets were superior to those obtained with 5-card sets. Ink blots and straight lines gave equal results, superior to those with colored figures; the lowest results were obtained with black figures. In experiments with 5-card sets including 5 tests for each kind of material, the score was 48 R., 3 H.R., 2 H.W., 40 W., and 7 N. from 100 T.

*H-n.* In 10 tests with 5-card sets of colored figures the score was 38 R. and 12 W. from 50 T., and in 5 tests with 10-card sets of straight lines 35 R. and 15 W. from 50 T.

These results, although obtained for the purpose of making suitable selection for the main part of the work, indicate that the span of memory varies greatly with different individuals and in less degree with different materials for the same individual.

## 2. RETENTION

A series of tests were made for recognition with a short period of time elapsing between presentation and selection. This interval was counted from the exposure of the last card in a series.

*Experiments with Pictures.* *McG.* 5-card sets were used. 10 tests with an interval of 30'' between exposure and selection resulted in 41 R. and 9 W. from 50 T. 10 additional tests were made, five with an interval of 30'' and five with an interval of 60'' between exposure and selection. The results were:—with 30'' interval 15 R., 2 H. R., 6 W., and 2 N. from 25 T., and with 60'' interval 20 R. and 5 W. from 25 T. In the 20 tests there is a total of 76 per cent R. The immediate recognition tests, with exclusion of the first five which served to familiarize the subject with the experiments, gave 88 per cent R. The difference is 12 per cent R. The increase in the interval between exposure and selection from 30'' to 60'' did not reduce the results.

*E-n.* 10 tests were made with 5-card sets and with an interval of 60'' between exposure and selection. The number of R. was the same as for immediate recognition.

*H-n.* Tests with 5-card sets and with an interval of 60'' be-

tween exposure and selection resulted in only right selections. 5 tests with 10-card sets and with an interval of 60'' gave 86 per cent R. as against 92 per cent R. in the immediate recognition tests.

*Experiments with Figures. McG.* In tests with 3-card sets and with an interval of 60'' between exposure and selection the results were inferior to those obtained in immediate recognition tests. In experiments with 5-card sets including 5 tests for each kind of material the score was 54 R. and 46 W. from 100 T. Comparing this score with that in immediate recognition we find that the former is higher by 6 per cent both in R. and in W., with an absence of other than R. and W. selections.

*H-n* was tested only for colored figures. 10 tests of 5 cards each and with an interval of 60'' between exposure and selection gave 38 R. and 12 W. from 50 T. which is identical with the result in the corresponding experiment for immediate recognition.

These results indicate that while a lapse of 60'' between exposure and selection tends to reduce the results, nevertheless this tendency is not sufficiently general nor sufficiently marked for experimental purposes.

### 3. FREQUENCY

*McG* alone was tested for delayed recognition in a series of experiments in which the exposure of 5 cards after the manner of the previous experiments was repeated with an interval of about 2'' between repetitions.

*Experiments with Pictures.* 10 tests with 5 repetitions and with an interval of 30'' between the last exposure and selection gave 48 R. and 2 W. from 50 T. 10 similar tests in which the interval, however, was 60'' gave 48 R., 1 H. R., and 1 W. from 50 T. There is a total of 96 per cent R. as against 76 per cent R. in the corresponding experiments without repetition.

*Experiments with Figures.* Tests with 5 repetitions gave the same results as were obtained in experiments without repetition. The subject became drowsy during the experiments. With only 3 repetitions and with an interval of 60'' between the last ex-

posure and selection the average results for the different kinds of figures show an increase of 15 per cent R. over those in experiments without repetition.

#### 4. RETROACTIVE INHIBITION

A few experiments performed with *McG* in which a second set of cards was presented in the interval between exposure and selection of the primary set failed to show a derogatory influence of retroactive inhibition.

## II. METHOD

### I. MATERIAL

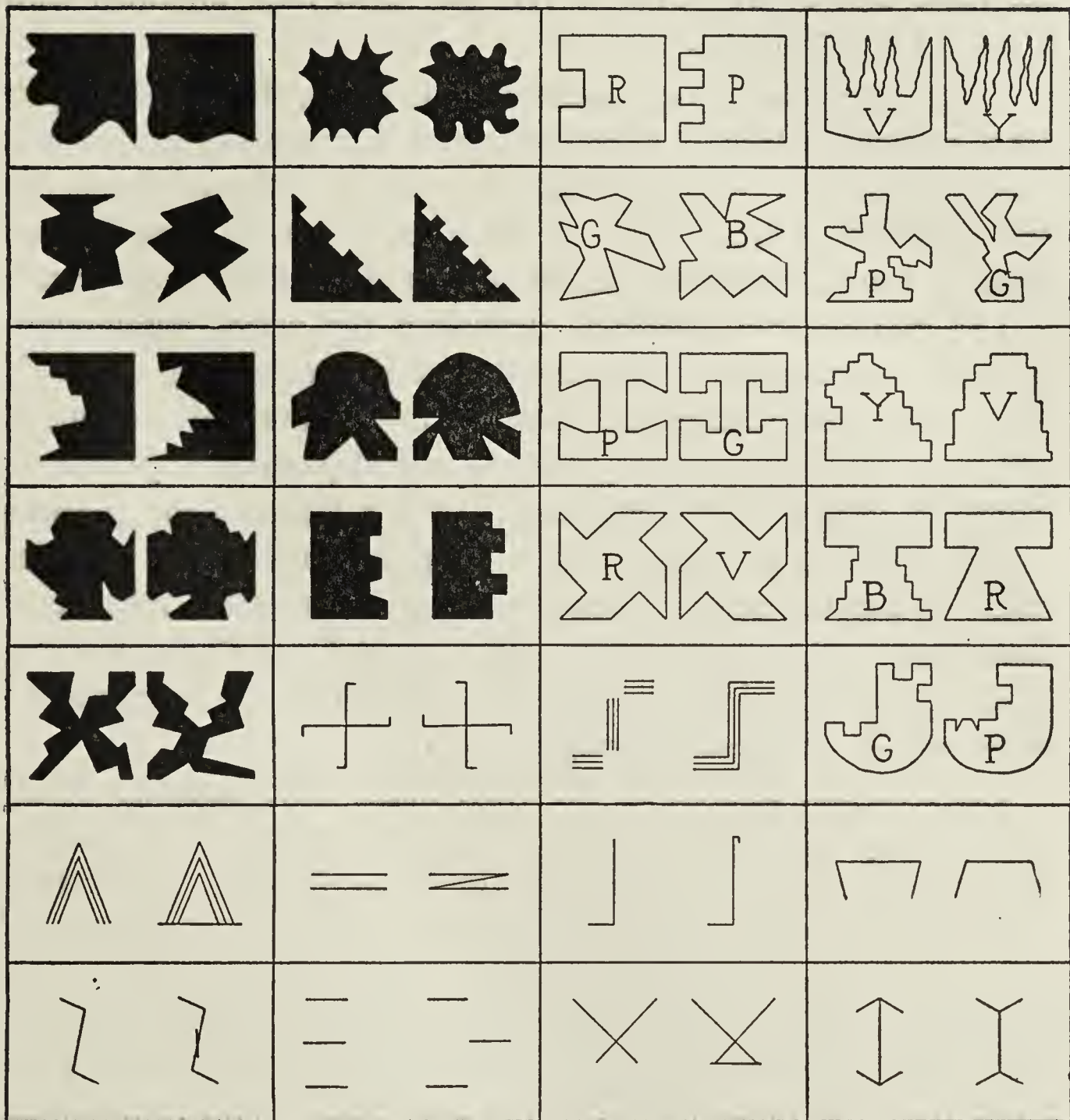
The material used in the present investigation has already been briefly described in the account of preliminary experiments. It consisted of two main groups, pictures of objects and irregular figures.

The pictures were of two kinds, colored and half-tone pictures, arranged in separate series and mounted on white cards  $3\frac{1}{2}''$  x  $4''$ . They were gathered from illustrated magazines and commercial catalogues and represent familiar objects such as men, women, and children in different situations, domestic and wild animals, articles of clothing, furniture and household articles, farm implements, fruits, flowers, and vegetables, houses, boats, vehicles, etc.

There were four kinds of irregular figures, black and colored figures cut from paper, straight lines drawn in black on white paper, and black ink blots on white paper. These were arranged in different series. In designing the material care was taken to avoid resemblance to objects so that the naming of the figures by the subject would be excluded. The figures were mounted like the pictures. Plate I shows some specimen of black figures, colored figures, and straight lines, grouped in pairs.

The whole material comprised one series of three hundred colored pictures, one of eight hundred half-tone pictures, and one series of one hundred of each of the four kinds of irregular figures.

In each picture series the cards were arranged in pairs so that the two pictures in a pair had a certain resemblance without being alike. Thus an Airdale and a Boston terrier, a fat butler and a fat clergyman, a boy and a girl at play, a knife and a fork, a razor and a safety razor, etc., formed pairs in the picture series. The figures were similarly arranged so that the general form and outline was common to the members of a pair and the details formed the differentiating element.



INCH SCALE

B - blue  
 G - green  
 P - pink  
 R - red

V - violet  
 Y - yellow  
 ■ - black

PLATE I.—Specimen of black figures, colored figures, and straight lines, forming part of the material used in experiments with “figures.” Each section of the plate contains a pair of “figures.”

The cards were numbered on the reverse side, each series separately, so that an odd and the subsequent even number marked the two members of a pair. The irregular figure series were then mixed in such a manner that a new series was formed in which five pair of black figures were followed by five pair of colored, these by five pair of straight lines, these by five pair of

ink blots, and so on. Thus mixed, the cards were provided with a second serial number.

There were now three main series of cards, the half-tone pictures numbered from 1 to 800, the mixed irregular figures numbered from 1001 to 1400, and the colored pictures numbered from 2001 to 2300. Each of these series was divided in two piles, one containing the odd, the other the even numbered cards.

The material was designed primarily for visual stimulation. In experiments made for the purpose of comparison between different materials Kirkpatrick<sup>1</sup> and Calkins<sup>2</sup> established the superiority of visual over auditory stimuli, and of pictured objects over words in tests of recall memory. In our material the pictures would therefore be expected to offer great facility for recollection. When the subject names them at presentation they occasion, besides the visual, also auditory and kinaesthetic stimulation. They are rich in associations and may be remembered mediately in terms of language.

The irregular figures, on the other hand, offer material which at least largely eliminates other than visual memory. The character of this material excludes its use in recall tests. In tests of five cards the series presented is uniform, that is, it is limited to one of the four sub-groups, and the subject has to select from among ten cards. Hence, the memory tested is that of the details which differentiate five individual figures of one of the four kinds from five other figures of the same kind. This differentiation is of visual quality and cannot easily be expressed in terms of language. The test is therefore, at least in a high degree, one of visual and immediate memory.

## 2. APPARATUS

In the main experiments the following apparatus was used:

a. An ordinary fall apparatus for exposing the cards for desired intervals of time of the character of an Atwood machine. The slide was counterbalanced with lead weights and had an adjustable opening. By adjusting this opening and interchang-

<sup>1</sup> *Psychol. Rev.*, Vol. I, p. 602.

<sup>2</sup> *Psychol. Rev.*, Vol. V, pp. 451-62.

ing three counterbalancing weights the time of exposure of a card could be set for from 1" to 1/50". Tuning fork records of the times of fall showed a maximum inaccuracy of 5 per cent.

b. A large pasteboard tray divided by pasteboard strips into thirty equal squares large enough to hold one card each. The squares were numbered from one to thirty, the numbers being irregularly distributed. There was an additional tray for twenty cards to be used in experiments requiring presentation of more than thirty cards.

c. A black satin curtain suspended from the horizontal arm of a rod the vertical arm of which was fastened to the laboratory table. The arms of the rod were about four feet long. The curtain when drawn out would hide from the subject the tray, the piles of cards, and the hand of the experimenter manipulating the cards; when drawn aside it would expose the cards on the tray to the subject's view.

d. An ordinary watch was used for recording time other than time of exposure.

### 3. PROCEDURE

#### A. General

The general procedure of the experiment was as follows. The subject was seated facing the laboratory table with the fall apparatus exposed and the curtain hiding the tray. The experimenter stood on the left side of and behind the fall apparatus, the cards to be used were placed out of sight of the subject. Immediately before each experiment its nature was carefully explained to the subject.

The "method of selection" was used in recognition tests. It has been stated that the cards were arranged in pairs and numbered with an odd and the subsequent even number in each pair. If five odd numbered cards were to be used in a test the corresponding even numbered cards would first be placed in their proper position on the tray. The spatial relations of the exposed and non-exposed cards were changed from test to test. The apparatus having been adjusted for the desired time of ex-

posure the experimenter would then expose one by one the odd numbered cards in the apparatus and after each exposure put them in place on the tray. The exposure of the series completed, there were ten cards on the tray, five of which had been seen, and the other five not seen by the subject. The curtain was then drawn aside either immediately or after a desired interval of time, and the subject was told to pick out the cards he had seen.

In recall tests the same procedure was followed, but before the curtain was drawn aside for selection the subject was told to report orally the cards he had seen. The recall tests were thus combined with recognition tests.

### B. The Experiments

Two general methods of testing were used as indicated above, that of recognition by selection and that of reproduction by recall. The recognition method was used with all the material, in addition to which the recall method was used with the colored and the half-tone pictures only.

There were five variable factors in the experiments.

a. *Material.* The role of this factor was to differentiate visual-auditory-kinaesthetic-mediate from visual-immediate memory. Experiments with half-tone pictures in which time of exposure, number of cards to the test, and interval between exposure and selection were variable were repeated with figures in order to show any difference in memory for different materials under various conditions. The colored pictures were used in two similar experiments, one of which served partly as an introductory experiment for the purpose of absorbing the primary, passing inefficiency of the subjects. The other experiment was placed number six in the series for the purpose of establishing, by way of comparison with the first, a possible change in the subject's efficiency during prolonged experimentation.

b. *Interval between exposure and selection.* This factor was introduced to give separate expression of apprehension and of retention. The first six experiments were divided into sets containing three to six tests each. Some of these sets were for im-



mediate recall followed by delayed recognition. In four experiments the remaining sets were arranged in pairs of tests for immediate recognition and of tests for recognition after an interval of three minutes counted from the completed exposure of the last card. In tests with normal subjects the interval was increased to five minutes. In each of these experiments there is one and the same variable factor within all the sets of tests, viz. time of exposure in Exp. II and III, and number of cards in Exp. IV and V, and another variable factor between the sets, viz. time elapsing between exposure and selection.

c. *Number of Cards.* The preliminary experiments indicated that some subjects could remember about five and others about ten cards with a reasonable proportion of error. We have therefore accepted five and ten cards as the "normal" sets of cards for the two groups of subjects respectively. The "normal" set was used in all experiments with pictures and with figures in which the number of cards to the test was constant. In other experiments in which the time was constant the number of cards forms the variable factor. There were four variations, the sets comprising 5, 10, 15, and 20 cards respectively for the group using the "normal" 10-card set and 3, 5, 7, and 9 cards respectively for the group using the "normal" 5-card set. In experiments with normal subjects the "normal" set comprised 15 cards, and the variables were 5, 10, 15, 20, and 25.

d. *Time of Exposure.* The preliminary experiments showed one second to be amply sufficient time of exposure. As a fact, it was later found that with some subjects almost identical results were obtained with exposure of  $1/5''$ . Exposure for one second was used in the experiments with colored pictures. In the experiments with half-tone pictures and with figures in which time of exposure formed the constant factor it was reduced to  $1/5''$ . In the experiments with half-tone pictures and with figures in which time of exposure was a variable factor five variations were made, viz.  $1''$ ,  $1/5''$ ,  $1/10''$ ,  $1/25''$ , and  $1/50''$ . These variations were designed to modify the intensity of stimulation.

e. *Frequency.* Only a few experiments were performed with

half-tone pictures for recall memory in which each series of cards was exposed four times.

### C. Experimental Procedure

To provide for variation in the different factors the experiments were arranged in eight groups to be known hereafter as Experiments I to VIII. They succeeded one another in numerical order.

Experiments I and VI were alike in character. One experiment day was given to each. The material was colored pictures; time of exposure was 1". The "normal" set of 5 cards was used for two subjects, McG and E-n, that of 10 cards for two other subjects, H-n and D-n. With each subject of the first group each experiment comprised 5 tests for immediate recognition, and 5 for recall and delayed recognition combined. With each subject of the second group Exp. I comprised 2 tests for immediate recognition and an equal number for recall and delayed recognition combined, and Exp. VI. 5 tests each for immediate recognition and for recall and delayed recognition combined. This gave a total of 34 tests for immediate recognition and an equal number for recall and delayed recognition, or a grand total of 68 tests.

Experiment II was performed with half-tone pictures. The "normal" set of 5 cards was used with two subjects, McG and E-n, and that of 10 cards with two other subjects, H-n and D-n. Variable factor: time of exposure. With McG the experiment covered eight, with each of the remaining subjects five experiment days. The experiment comprised 40 tests per subject in the first group, distributed with 15 tests each for immediate and delayed recognition and 10 tests for recall and delayed recognition combined. McG had 1 additional test each for immediate recognition and for recall and delayed recognition combined. In the second group H-n had 12 tests for immediate, and an equal number for delayed recognition, and 5 for recall and delayed recognition combined. D-n had 8 tests for immediate and 9 for delayed recognition, and 4 for recall and delayed recognition combined. This made a total of 51 tests for immediate and for

delayed recognition each, and 30 for recall and delayed recognition combined, or a grand total of 132 tests. The distribution of these tests over the varying factor may be seen in Tables V, VII, IX, and XI in which, however, among the tests for exposure of  $1/5''$  are counted also those for the "normal" set of Exp. IV. E-n could not be tested for exposures of shorter duration than  $1/10''$ .

Experiment III was performed with figures. It was otherwise essentially a reproduction of Exp. II, with the exception that recall tests were lacking. With McG it was distributed over four, with the remaining subjects, over five experiment days. McG and E-n had each 20 tests for immediate and 20 for delayed recognition. H-n had 10 tests for immediate and 12 for delayed recognition. D-n had 10 tests each for immediate and for delayed recognition. The total was 60 tests for immediate and 62 for delayed recognition, or a grand total of 122 tests. The distribution of these tests over the varying factor may be seen in Tables VI, VIII, X, and XII, in which the tests for "normal" set of Exp. V are counted among those for exposure of  $1/5''$ . E-n could not be tested for exposures of shorter duration than  $1/25''$ .

Experiment IV was performed with half-tone pictures. The time of exposure was  $1/5''$ . Variable factor: number of cards to the test. McG and E-n were tested with 3, 5, 7, and 9 cards; H-n and D-n with 5, 10, 15, and 20 cards. The experiment was divided over five experiment days with McG and D-n, and over four with E-n and H-n. With each subject of the first group (McG and E-n) it comprised 12 tests for immediate recognition, 12 for delayed recognition, and 9 for recall and delayed recognition combined. With H-n it included 5 tests for immediate and delayed recognition each, and 7 for recall and delayed recognition combined, and with D-n 7 tests for immediate and delayed recognition each, and 8 for recall and delayed recognition combined. This makes 36 tests for immediate and delayed recognition each and 33 tests for recall and delayed recognition combined, or a grand total of 105 tests. The distribution of these tests over the varying factor may be seen in Tables XIII, XV, XVII, and XIX.

Experiment V was performed with figures. It was otherwise essentially a repetition of Exp. IV with the exception of lacking recall tests. With D-n it was distributed over three, with McG, E-n, and H-n over four experiment days. McG and E-n each had 16 tests for immediate and an equal number for delayed recognition. H-n and D-n each had 10 tests for immediate and an equal number for delayed recognition. The total was 52 tests for immediate and delayed recognition each, or a grand total of 104 tests. The distribution of these tests over the varying factor may be seen in Tables XIV, XVI, XVIII, and XX.

Experiment VII was performed with half-tone pictures. The "normal" set of 10 cards was used with two subjects, H-n and D-n. It covered five experiment days with each subject. Each day 4 tests were made with each subject in the following manner. 7 cards of the set were exposed in succession for  $1/5''$  each, and after a lapse of 2' the subject was told to recall the pictures seen. Three minutes were allowed for the recall, after which time the same 7 and one additional card were exposed and the procedure after exposure repeated. Thus for each test one card was added so that in the fourth test 10 cards were exposed. 20 tests were made with each subject, making a total of 40 tests.

Experiment VIII was arranged in the same manner with the exception that 30'' after each exposure of a set an equal set of colored pictures was exposed, each for  $1/5''$ . Thus each series of half-tone pictures was followed by an equal series of colored pictures. 2' after exposure of the half-tone picture series the subject was made to recall the pictures in that series. The experiment covered five experiment days with each subject. Each subject had 20 tests, making a total of 40 tests.

In all the experiments each subject was tested for a maximum of one hour on each experiment day. A card was used only once with each subject, but the two series of odd and even numbered cards were used alternately, always, however with an interval of at least two weeks.

## 4. METHOD OF SCORING

Woodworth's method of scoring in recognition consists in subtracting from total presentations omissions and twice the errors. The last item eliminates the factor of guessing on the supposition that in a sufficiently large series the number of guesses is equally distributed over right and wrong selections. For every wrong selection there would therefore be a right guess, and the total number of guesses is twice the errors.

It is desirable also to provide for the factor of hesitation in selection for which reason we arbitrarily give selection after hesitation half the value of selection without hesitation. To compare the scores for groups using normal sets of different size and for tests in which the number of cards is varied we express the score in per cent value. We arrive at the following formula for recognition score, used in the present investigation.<sup>3</sup>

$$\frac{(T - N - 2W - HW - \frac{HR}{2}) \times 100}{T} = \text{Score per cent.}$$

In the recall score the factors of guessing and of hesitation obviously need not be considered, and the formula will be:

$$\frac{100 R}{T} = \text{Score per cent.}$$

<sup>3</sup> For meaning of letters in formula see p. 4, n. 1.

### III. EXPERIMENTS WITH NORMAL SUBJECTS

For the purpose of comparing the memory of defective with that of normal individuals a series of experiments were made with subjects of the latter group. Ten subjects were chosen and divided into two equal groups to be known as A and B respectively. Group A consisted of one executive secretary (F-n), one teacher (C-n) and one student (L-d) at a Social Service School, one executive Social Service Worker (C-1), all female, and one colored maid (G-n). Group B consisted of two teachers (E-g and C-h) and one student (M-n) of the aforesaid Social Service School, one Government clerk (M-r) all female, and one male college graduate (R-s). The age of these subjects varied from twenty to thirty-five years.

The method described in the foregoing section was applied with certain modifications. Only Exp. II to V were made. The "normal" set of cards was extended to 15 items, retention time in tests for delayed recognition was increased to 5 minutes, and in Exp. IV and V tests with 25 cards to the set were added. Experiments II and III were made only with the subjects of group A, Experiments IV and V only with those of group B. The experiments with pictures (II and IV) were distributed over three, those with figures (III and V) over two experiment days with each subject.

The number and distribution of tests in each experiment and the results are shown in Tables I-IV. The results are also represented in Figures 1 and 2.

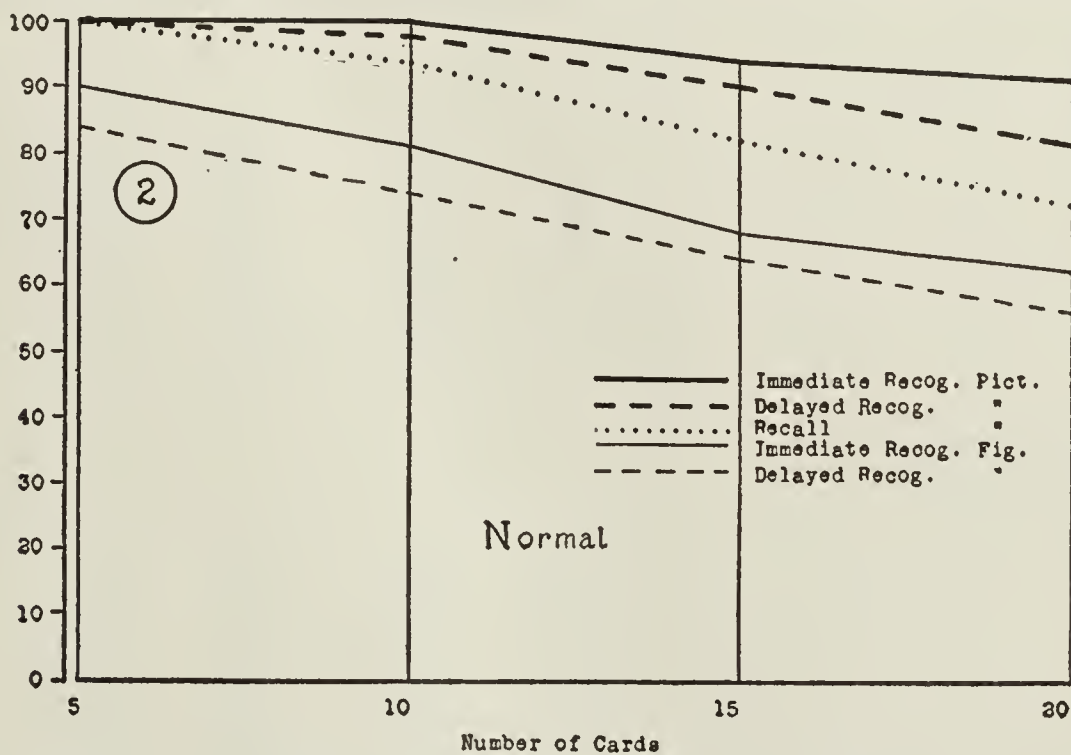
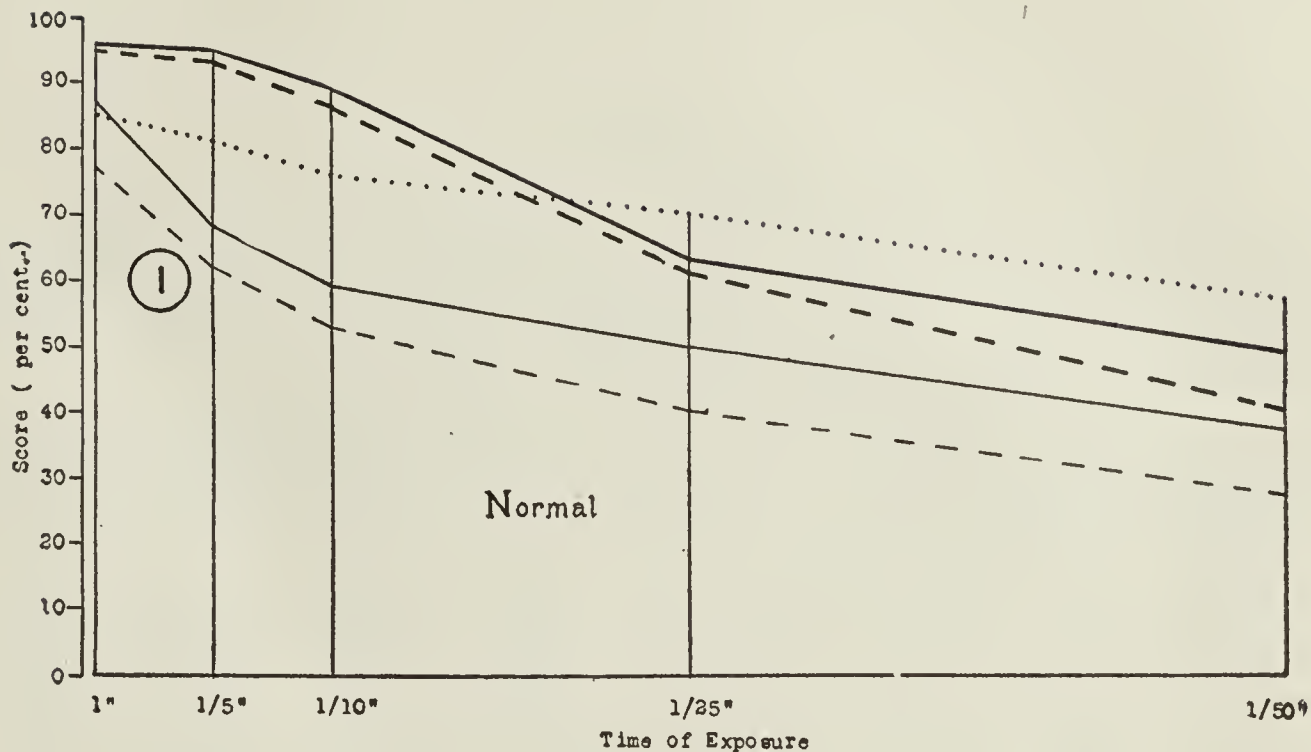


FIG. 1.—Variation in Time of Exposure. Per cent scores.

FIG. 2.—Variation in Number of Cards. Per cent scores. Both figures show the average results for normal subjects.

TABLE I

*Experiments with Normal Subjects.**Selection from Half-tone Pictures. Variation in Time of Exposure.*

15 cards shown in succession. Immediate recognition and recall. In delayed recognition retention time 5 minutes. 24 experiments with each subject equally distributed over tests for immediate recognition, recall and delayed recognition. Figures give per cent score.

a. <i>Immediate Recognition</i>	<i>Time of Exposure</i>				
	1"	1/5"	1/10"	1/25"	1/50"
Number of tests	1	2	2	1	2
Subjects					
F-n .....	100	100	97	67	67
L-d .....	93	93	93	60	53
C-n .....	100	100	97	53	33
C-l .....	87	87	60	47	60
G-n .....	100	97	100	87	33
Average .....	96	95	89	63	49
b. <i>Recall</i>					
Number of tests	1	2	2	1	2
Subjects					
F-n .....	93	87	87	80	73
L-d .....	87	80	67	60	53
C-n .....	80	73	67	67	40
C-l .....	80	80	73	67	53
G-n .....	87	87	87	77	67
Average .....	85	81	76	70	57
c. <i>Delayed Recognition</i>					
Number of tests	1	2	2	1	2
Subjects					
F-n .....	95	100	87	67	47
L-d .....	93	87	93	60	40
C-n .....	100	93	90	40	27
C-l .....	87	87	73	47	47
G-n .....	100	100	87	93	40
Average .....	95	93	86	61	40



TABLE II

*Experiments with Normal Subjects.*

*Selection from Figures. Variation in Time of Exposure.*

15 cards shown in succession. Immediate and delayed recognition. In delayed recognition retention time 5 minutes. 6 experiments for immediate and 7 for delayed recognition with each subject. Figures give per cent score.

	<i>Time of Exposure</i>				
	1"	1/5"	1/10"	1/25"	1/50"
<i>a. Immediate Recognition</i>					
Number of tests	1	2	1	1	1
Subjects					
F-n .....	87	73	67	53	33
L-d .....	80	60	47	27	33
C-n .....	93	73	60	60	40
C-l .....	73	47	33	33	20
G-n .....	100	87	87	77	60
Average .....	87	68	59	50	37
<i>b. Delayed Recognition</i>					
Number of tests	1	2	1	1	2
Subjects					
F-n .....	80	53	47	27	20
L-d .....	60	47	36	20	20
C-n .....	73	67	60	20	13
C-l .....	87	60	47	47	33
G-n .....	87	87	77	87	47
Average .....	77	62	53	40	27

TABLE III

*Experiments from Half-tone Pictures. Variation in Number of Cards.*

Cards shown in succession for 1/5". Immediate recognition and recall; in delayed recognition retention time 5 minutes. 27 experiments with each subject equally distributed over tests for immediate recognition, recall, and delayed recognition. Figures give per cent score.

	<i>Number of Cards</i>				
<i>a. Immediate Recognition</i>	25	20	15	10	5
Number of tests	2	2	2	2	1
Subjects					
E-g .....	92	98	100	100	100
C-h .....	82	84	88	100	100
M-n .....	82	84	89	100	100
M-r .....	84	90	93	100	100
R-s .....	96	100	100	100	100
Average .....	87	91	94	100	100
<i>b. Recall</i>					
Number of tests	2	2	2	2	1
Subjects					
E-g .....	80	80	80	100	100
C-h .....	48	60	87	95	100
M-n .....	44	55	67	85	100
M-r .....	80	80	87	90	100
R-s .....	76	85	87	100	100
Average .....	66	72	82	94	100
<i>c. Delayed Recognition</i>					
Number of tests	2	2	2	2	1
Subjects					
E-g .....	76	80	100	90	100
C-h .....	48	72	72	100	100
M-n .....	62	72	89	100	100
M-r .....	72	80	90	100	100
R-s .....	96	100	100	100	100
Average .....	71	81	90	98	100

TABLE IV

*Experiments with Normal Subjects*

*Selection from Figures. Variation in Number of Cards.*

Cards shown for 1/5" in succession. Immediate and delayed recognition. In delayed recognition retention time 5 minutes. 14 experiments with each subject equally distributed over tests for immediate and for delayed recognition. Figures give per cent score.

	<i>Number of Cards</i>				
<i>a. Immediate Recognition</i>	25	20	15	10	5
Number of tests	1	1	2	2	1
Subjects					
E-g .....	76	80	87	100	100
C-h .....	52	60	60	65	80
M-n .....	36	50	60	80	90
M-r .....	36	40	47	60	80
R-s .....	80	80	87	100	100
Average .....	56	62	68	81	90
<i>b. Delayed Recognition</i>					
Number of tests	1	1	2	2	1
Subjects					
E-g .....	68	70	87	90	100
C-h .....	52	50	60	60	70
M-n .....	28	40	47	70	80
M-r .....	36	40	40	50	70
R-s .....	76	80	87	100	100
Average .....	52	56	64	74	84

#### IV. THE ABNORMAL SUBJECTS

Four subjects, patients at St. Elizabeth's Hospital in Washington, D. C., with memory defects associated with organic psychoses were selected for special investigation. Brief histories, so far as they are essential to the present study, follow; many details have been omitted.

*McG.* Male. Age 40 years. Born in U. S. Unmarried. Former sailor in U. S. Navy. Psychosis associated with cerebrospinal syphilis.

Family history negative. The subject went to school up to his fourteenth year when he became a mechanical laborer; later he enlisted in the U. S. Navy. He used alcohol as a rule moderately but occasionally to excess. In 1908 he contracted syphilis and received immediate treatment. A year later a stiffness appeared in his left arm and leg. He received hospital treatment and was able to return to duty and after expiration of his enlistment in 1912 to resume his occupation as a laborer. On admission to St. Elizabeth's Hospital in November 1914 the subject had no memory of the events leading to his being sent there and was unable generally to give information about himself. Neurological examination showed poor grip, weaker on the left than on the right side. There was apparent spastic paralysis of the muscles of the left side, the left foot being extended on the leg and almost immovable. The muscles of the face were greatly paralyzed. The left side showed a Babinski and ankle clonus. All deep reflexes were exaggerated; the gait was unsteady and stiffened with dragging of the left foot. A mental test in February 1915 gave the following results:—Special memory test deficient. Simple calculation good. Months and days were given correctly forward and backward, and figures of four digits were given correctly and transposed. General information good. Memory of current events deficient. Since this time the subject has undergone a gradual deterioration. The following diagnosis

was made. Cerebrospinal syphilis. Lacunar softenings with involvement on both sides. The lesions are probably:—Right side, extensive in the internal capsule; left side, of very slight extent in the capsule. There may also be cortical lesions; possibly also some in the posterior portion of the internal capsule or the thalamus, and in the spinal cord.

In the laboratory the subject showed lack of orientation, decreased power of conception and observation, and retrograde and anterograde amnesia. He was willing to assist at the experiments but was noisy and talkative and failed to pay voluntary attention to his tasks. He would constantly repeat the same stream of talk, ending with a song. He did not remember from day to day the answers to the same questions he asked almost daily for months. Incidents with strong emotional setting, however, were remembered but always referred to as of more recent occurrence. He had no memory of events following the infection and confabulated when asked about that period.

*E-n.* Male. Age 64 years. Born in Sweden. Married. Former sail-maker's mate in U. S. Navy. Senile or pre-senile psychosis.

Family history unknown. The subject went to school from his eighth to his nineteenth year. At twenty-two he went to sea. He states that he was a moderate user of alcohol and tobacco. He suffered with mental confusion in 1917 and was taken to a Naval hospital where he was found disoriented, confused, and lacking insight. There were traces of sugar in the urine. After diet and treatment the urine became sugar free, but the mental condition persisted. On admission to St. Elizabeth's Hospital in December 1917 his physical condition was fair, but he was nervous. He showed himself disoriented in all fields. His memory was poor for recent events, special memory was also very poor. The months and days were given correctly forward and backward. He could transpose three digits. He had no knowledge of current events, and his ability for calculation was poor. His talk was generally relevant and coherent, but sometimes he became confused and spoke in an irrelevant and incoherent man-

ner. He was quite disoriented and lacked insight and judgment. He gave his age usually as 104 or 163 years, once or twice he gave his real age. On a hot July day he would say that it was January and that there ought to be snow. Occasionally he would laugh to himself, on other occasions his face would contract as if he were going to cry.

In the laboratory he was very tractable and quiet. He was willing to coöperate but often became distracted and failed to attend to the tests voluntarily. He complained of poor eye-sight, received glasses but could not be made to use them. When the cards were presented for selection he would usually show surprise, deny having seen any, or say that he had seen all. When told that he had seen five of the ten cards he would look at the cards, slowly take one by one and, on being questioned, admit or deny that he had seen them. At other times he would make a rapid selection.

*H-n.* Male. Age 54 years. Born in U. S. Married. Retired Army Officer. Psychosis associated with cerebral arterio-sclerosis.

Family history negative. The subject had yellow fever in 1899 and later, while in the Philippines, malaria, dengue, and dysentery. He was a moderate user of alcohol. While serving in the Philippines in 1904 he developed severe intestinal trouble and was subsequently returned to the U. S. On the journey home he was very weak, was unable to stand, became cross-eyed, and had hallucinations and delusions. There is complete amnesia for the two years following this period. He was retired from service. From this time to 1917 his symptoms were confusion of ideas, poor memory and lack of interest in current events. During the war he served for a year as Quartermaster but was finally relieved from duty because of discrepancies in his accounts. At that time he showed amnesia particularly for recent events. He had had various neurasthenic complaints. On admission to St. Elizabeth's Hospital in October 1920 the subject was found physically well developed. Neurological examination showed:—Muscle power equal, fairly good and fairly well sustained. Reflexes:

upper extremities equal and normal, corneal and pharyngeal present, abdominal not obtained, patellar decreased, no ankle jerks. Slight swaying in Romberg, no Babinski, lack of coördination of fingers to nose, slight tremors of outstretched fingers. The subject was oriented and no hallucinations or delusions were elicited. He had a fair knowledge of current events. There was a gross memory defect with poor memory for details. Dates of historical events were given correctly but details were lacking. Names of childhood associates and details of events in his own life were poorly recalled. His conversation was slow though relevant and coherent. He was diagnosed first as undifferentiated psychosis with depression, and in December 1920 this was corrected to psychosis associated with cerebral arterio-sclerosis. In the spring of 1921 he was improved. Outside his memory defect there were practically no mental symptoms at the time. A hospital note of September 1921 records a further improvement, particularly in his memory for past events.

In the laboratory his manner and conversation were in every respect normal. He coöperated excellently in the experiments and showed a great desire to get well. He was most enthusiastic over the tests which he thought to be therapeutic.

*D-n.* Female. Age 53 years. Born in U. S. Widow. Toxic psychosis, Korsakow type.

The subject has a sister who is an imbecile. A brother used alcohol to excess and committed suicide. The father also used alcohol to excess, the mother moderately. She comes of a socially prominent family and has enjoyed a refined education. In her youth she had a successful career on the dramatic stage. She had literary talent. At the time of the death of her husband in 1906 she was depressed and indifferent to her surroundings, she had previously been using alcohol to excess and probably also morphine and cocaine. On admission to St. Elizabeth's Hospital in August 1907 she had multiple neuritis, optic atrophy, weak heart, and a tendency to constipation. Neurological examination showed:—Tingling sensation in the fingers of both hands. Grip in both hands very weak. Plantar reflexes diminished, especially on left side, patellar and Achilles reflexes absent, no ankle clonus.

Sensation for light touch diminished, and to heat and cold normal in both arms and legs. Sensation over trunk, taste, smell and hearing normal. Pain on pressure over popliteal nerve on the left leg—none on the right. There were no areas of anaesthesia, no girdle pains, no gastric crises. She was unable to stand unaided, and, when assisted in standing, her feet and legs became cyanosed. The mental symptoms were:—Clouding of consciousness, fatigue on slight mental exertion, and slight apprehensiveness. She had some insight into her own condition. The intelligence test was good, the attention test fair. Delusions and hallucinations were recorded previous to her admittance to the hospital. Memory for recent events was poor and associative memory defective. There was marked falsification of memory, disorientation for time and place, and a tendency to confabulation and to indulgence in pseudo-reminiscences. In January 1909 she was greatly improved. Her physical health was good, she was oriented as to time, place and person, showed good judgment and reasoning, and appeared mentally normal but for slight memory defect. Her memory seemed normal for events up to the outbreak of the psychosis, following which there is a period of complete amnesia. A memory test in 1914 showed:—Associative memory good, general information good, memory for current events faulty. In June 1918 she was discharged as sufficiently improved to take up outside work, but returned in 1920 with a recurrence of her psychosis. At the time of the present investigation the subject enjoyed good physical health. She was engaged in simple clerical work for the hospital. She appeared mentally normal but for a slight impairment in judgment, a certain emotional instability, and a defect in memory for recent events. She coöperated well in the experiments and was anxious to make a recovery.



## V. INDIVIDUAL RESULTS

### I. VARIATION IN TIME OF EXPOSURE

*Subject: McG*

*Experiments with Pictures.* Experiment II gave the following results (Table V). In immediate recognition the score is 73 per cent for exposure of 1" and declines rapidly for shorter exposures, being 54, 53, 20 and 6 per cent respectively for exposures of 1/5", 1/10", 1/25", and 1/50". There is no appreciable difference between the results for exposures of 1/5" and 1/10", but the difference between these figures and the 73 per cent obtained for exposure of 1", together with the total difference of 67 per cent between the results for 1" and 1/50" exposures show that short exposures prevented clear apprehension. This is further borne out by the complaint of the subject that the experimenter was "going too fast," particularly with exposures of 1/25" and 1/50".

A similar rapid decline is found in the results for delayed recognition. The scores are 60, 33, 33, 20, and 7 per cent for exposures from 1" to 1/50" respectively. Comparing these results with those for immediate recognition we find that for exposures of 1", 1/5", and 1/10" there is a considerable difference in score, which difference is wholly or practically absent in the results for exposures of 1/25" and 1/50". The differences for the three longer exposures, counting from that of 1", are 13, 21, and 20 per cent respectively. These differences we would associate with the lapse of time between exposure and selection. It would then seem that the low results obtained with the two shortest exposures in delayed recognition are due not to the transformation of the mental impression in the interval of 3 minutes, but to poor apprehension.

The results for delayed recognition after recall are, as a whole, lower than those for delayed recognition without recall. The scores are 47, 44, 10, 20, and -20 per cent for the respective ex-

TABLE V

*Summary of Experiments with Pictures and Variation in Time of Exposure.*  
*Subject: McG.*

1. *Immediate Recognition*

No. of Exp't	Time of Exposure	R	Hes.		W	N	T	Score per cent	No. of Tests
			R	W					
II.	1"	12	-	-	3	-	15	73	3
II. and IV.	1/5"	27	-	-	8	-	35	54	7
II.	1/10"	23	-	-	7	-	30	53	6
II.	1/25"	6	-	-	4	-	10	20	2
II.	1/50"	8	-	-	7	-	15	6	3 21

2. *Recall and Delayed Recognition*

No. of Exp't	Time of Expos.	Recall						Score per cent	Delayed Recognition					Score per cent	No. of Tests	
		R	Hes.		W	N	T		R	Hes.		W	N			T
			R	W						R	W					
II.	1"	6	-	-	-	9	15	40	11	-	-	4	-	15	47	3
II. & IV.	1/5"	10	-	-	-	15	25	40	18	-	-	7	-	25	44	5
II.	1/10"	5	-	-	-	15	20	25	11	-	-	9	-	20	10	4
II.	1/25"	-	-	-	-	5	5	0	3	-	-	2	-	5	20	1
II.	1/50"	1	-	-	-	9	10	10	4	-	-	6	-	10	-20	2 15

3. *Delayed Recognition*

No. of Exp't	Time of Exposure	R	Hes.		W	N	T	Score per cent	No. of Tests
			R	W					
II.	1"	12	-	-	3	-	15	60	3
II. and IV.	1/5"	19	-	2	9	-	30	33	6
II.	1/10"	20	-	-	10	-	30	33	6
II.	1/25"	6	-	-	4	-	10	20	2
II.	1/50"	8	-	-	7	-	15	7	3 20

Total tests 56

posures. The effort to recall would therefore seem to be an interference with the recognition memory. In this connection it should be noted that the subject hardly ever could be made to remain quiet in the retention interval in experiments for delayed recognition without recall. He would attempt to talk about himself, to ask questions about the experimenter and the hospital physicians, or to sing: hence it is fair to assume that his mind would be occupied but not with the experiment. It is therefore not the mental occupation, but the particular effort to recall that differentiates the experiments for delayed recognition with and without recall. The difference in results must then be ascribed to the latter factor.

The results for recall are, on the whole, lower than those for recognition. For the respective exposures the scores are 40, 40, 25, 0, and 10 per cent. The recall memory is, therefore, less good

than the recognition memory. There are two considerable drops in the scores, one occurring with 1/10" and the other with 1/25" exposure. These drops must be ascribed to reduced apprehension as a result of decreased stimulation time.

*Experiments with Figures.* Experiment III gave the following results (Table VI). In immediate recognition the scores are 50, 27, 15, 10, and 8 per cent for the respective exposures from 1" to 1/50". In general these scores are lower than the corresponding scores for pictures, the differences for the various exposures being respectively 23, 27, 38, 10, and -2 per cent. With decreasing stimulation time these scores drop more rapidly than those for pictures up to and including exposure for 1/10", from then on the two series of scores converge, becoming practically identical for 1/50" exposure.

TABLE VI

*Summary of Experiments with Figures and Variation in Time of Exposure*  
Subject: McG.

No. of Exp't.	Time of Exposure	1. Immediate Recognition					Score per cent	No. of Tests	
		R	Hes. R	Hes. W	W	N			T
III.	1"	15	-	-	5	-	20	50	4
V.	1/5"	19	-	-	11	-	30	27	6
III.	1/10"	23	-	-	17	-	40	15	8
III.	1/25"	11	-	-	9	-	20	10	4
III.	1/50"	10	1	-	9	-	20	8	4
2. Delayed Recognition									
III.	1"	14	-	-	6	-	20	40	4
V.	1/5"	17	-	-	13	-	30	13	6
III.	1/10"	22	-	-	18	-	40	10	8
III.	1/25"	11	-	-	9	-	20	10	4
III.	1/50"	8	-	-	12	-	20	-20	4
								Total tests	52

With this material, therefore, apprehension also deteriorates rapidly with the decrease in stimulation time. In general, pictures offer greater facility for apprehension, but this advantage disappears when the stimulation time becomes sufficiently decreased.

In delayed recognition the scores for the respective exposures are 40, 13, 10, 10, and -20 per cent. The corresponding differences between these scores and those for immediate recognition

are 10, 14, 5, 0, and 28 per cent. Comparing these with the corresponding figures for pictures we find the present differences somewhat smaller and disappearing sooner than was the case with pictures. The retention time factor shows a considerable influence in reducing the scores for 1" and 1/10" exposure; for shorter exposures this influence decreases and the low results must be ascribed to poor apprehension.

Throughout the series of experiments it was noticed that the quality of the picture or figure presented did, to a certain extent, influence apprehension and memory. Pictures with girls, sailors, and ships made a stronger impression on account of their emotional connotation, as did also green and blue figures—the subject was Irish and a former sailor. He became more interested when material of this character was presented. In tests for recall this factor was very apparent; in tests for recognition it was not noticed to have an effect, since the subject was no more correct in his choice between two items of the pleasing character.

*Subject: E-n*

*Experiments with Pictures.* The results obtained in Experiment II are shown in Table VII. In immediate recognition the

TABLE VII

*Summary of Experiments with Pictures and Variation in Time of Exposure.*  
*Subject: E-n.*

1. Immediate Recognition												
No. of Exp't	Time of Exposure	R					Score per cent	No. of Tests				
		Hes. R	W	N	T							
II.	1"	33	—	—	17	—	50	32	10			
II. and IV.	1/5"	17	1	—	6	6	30	37	6			
II.	1/10"	9	—	—	2	9	20	35	4 20			

2. Recall and Delayed Recognition																
No. of Exp't	Time of Expos.	Recall					Score per cent	Delayed Recognition					Score per cent	No. of Tests		
		R	Hes. R	W	N	T		R	Hes. R	W	N	T				
II.	1"	5	—	—	—	20	25	20	11	—	—	5	9	25	24	5
II. & IV.	1/5"	4	—	—	—	21	25	16	10	—	—	8	7	25	8	5
II.	1/10"	3	—	—	—	17	20	15	2	—	1	1	16	20	5	4 14

3. Delayed Recognition												
No. of Exp't	Time of Exposure	R					Score per cent	No. of Tests				
		Hes. R	W	N	T							
II.	1"	27	2	—	14	2	45	31	9			
II. and IV.	1/5"	17	—	—	9	4	30	27	6			
II.	1/10"	6	—	—	2	17	25	16	5 20			

Total tests 54

scores are 32, 37, and 35 per cent for exposures of 1", 1/5", and 1/10" respectively. The subject was quite unable to make out the pictures when exposed for 1/25"—he would look up astonished and say that he could see nothing. For this reason the tests for 1/25" and 1/50" were not continued. The scores are low but show little variation. They are slightly better for exposure of 1/5", and 1/10" than for exposure of 1"; the best result is obtained with exposure of 1/5".

In delayed recognition there is more variation in the scores which are 31, 27, and 16 per cent for exposures of 1", 1/5", and 1/10" respectively. The scores decline at an increasing rate with the gradual shortening of the stimulation time. This difference between the two series of scores may find an explanation in the following facts. Table XXVII shows that in immediate recognition the last item exposed is most frequently selected, 80 per cent; the first and second, 63 per cent; the third, 60 per cent; and the fourth, 53 per cent. In delayed recognition the percentage selections from the five items are: fourth and fifth, 53 per cent; third, 50 per cent; and first and second, 43 per cent each. The greatest difference between the two scores, viz., 27 per cent, is found for the fifth item, the next greatest for each of the first two items, the difference for the third item is 10 per cent, and for the fourth there is no difference. The proportionately more frequent occurrence in immediate than in delayed recognition of the fifth item may be explained by the fact that in immediate recognition this item is selected immediately after having been exposed whereas new stimuli intervene between exposure and selection of the remaining items. If, therefore, we consider only the first four items, the percentages of selection are, counting from the first to the fourth item, in immediate recognition 63, 63, 60, and 53 per cent, and in delayed recognition 43, 43, 50, and 53 per cent. These figures present themselves in a descending scale for immediate and in an ascending scale for delayed recognition. This would suggest at least a more marked influence of retroactive inhibition in delayed than in immediate recognition, which factor in conjunction with the influence of re-

duction in stimulation time may explain the peculiar difference in the two scores.

The results for delayed recognition after recall are lower than those for delayed recognition without recall, the scores being 24, 8, and 5 per cent for exposures of 1", 1/5", and 1/10" respectively. The subject usually remained quiet in the interval between exposure and selection in experiments for delayed recognition without recall. We may ascribe the lower results and the more rapid decline in the score to a deleterious influence of the effort to recall upon recognition memory.

The recall score is lower than that for immediate as well as that for delayed recognition; it decreases with the shortening of the stimulation time. The figures are 20, 16, and 15 per cent for exposures of 1", 1/5" and 1/10" respectively.

*Experiments with Figures.* Table VIII gives the results of

TABLE VIII

*Summary of Experiments with Figures and Variation in Time of Exposure.*  
*Subject: E-n.*

No. of Exp't.	Time of Exposure	1. Immediate Recognition					T	Score per cent	No. of Tests
		R	Hes.		W	N			
			R	W					
III.	1"	22	1	—	7	—	30	52	6
V.	1/5"	23	—	—	7	—	30	53	6
III.	1/10"	27	—	—	13	—	40	35	8
III.	1/25"	15	—	—	8	7	30	23	6
2. Delayed Recognition									
III.	1"	19	—	—	10	1	30	30	6
V.	1/5"	19	1	—	10	—	30	32	6
III.	1/10"	21	—	4	15	—	40	15	8
III.	1/25"	15	—	—	13	2	30	7	6
								Total tests 52	

Experiment III. In immediate recognition the scores are 52, 53, 35, and 23 per cent for exposures from 1" to 1/25" respectively. It is to be noticed that the subject was able to discern the figures when the time of exposure was reduced to 1/25". With exposure of 1/50", however, he could not make out the figures, for which reason tests with this exposure were discontinued. In general these scores are higher than those for pictures; with exposure of 1/10" the results are the same for pictures and figures. As in

the scores for pictures the results with exposure of  $1/5''$  are better than those with  $1''$  exposure. The difference, however, for figures is less marked. The scores for figures decline rapidly after the  $1/5''$  mark has been reached.

It would then seem that figures offer greater facility for apprehension than pictures but that this advantage disappears with the shortening of the stimulation time to  $1/10''$ .

The scores for delayed recognition are on the whole considerably lower than those for immediate recognition. They are 30, 32, 15, and 7 per cent for the respective exposures. The differences between the two series of scores for the respective exposures are 22, 21, 20, and 16 per cent; there is, therefore, a somewhat sharper decline in the score for immediate than in that for delayed recognition. With pictures the opposite tendency appeared. The difference between the scores was negligible for  $1''$  exposure but increased rapidly for exposures of  $1/5''$  and  $1/10''$ . It is probable that retroactive inhibition is more pronounced in delayed than in immediate recognition, and we would therefore conclude that with figures this condition is not in evidence.

*Subject: H-n*

*Experiments with Pictures.* The following results were obtained in Experiment II (Table IX). In immediate recognition the scores are 95, 100, 93, 90, and 87 per cent for exposures of  $1''$ ,  $1/5''$ ,  $1/10''$ ,  $1/25''$ , and  $1/50''$  respectively. The results for  $1/5''$  exposure are better than those for  $1''$  exposure, below there is a gradual decline along the series. The difference between the highest and lowest figures in the score is small, viz: 13 per cent, hence a gradual shortening of the stimulation time from  $1/5''$  to  $1/50''$  has a moderate, derogatory effect on apprehension.

The score for delayed recognition is identical with that for immediate recognition with the exception that with exposure of  $1/50''$  the score is 7 per cent lower. An interval of 3' between exposure and selection has, therefore, practically no influence upon the results.

TABLE IX

Summary of Experiments with Pictures and Variation in Time of Exposure.  
Subject: H-n.

1. Immediate Recognition									
No. of Exp't	Time of Exposure	R	Hes.		W	N	T	Score per cent	No. of Tests
			R	W					
II.	1"	39	-	-	1	-	40	95	4
IV.	1/5"	20	-	-	-	-	20	100	2
II.	1/10"	29	-	-	1	-	30	93	3
II.	1/25"	19	-	-	1	-	20	90	2
II.	1/50"	28	-	-	2	-	30	87	3 14

2. Recall and Delayed Recognition																
No. of Exp't	Time of Expos.	Recall					Score per cent	Delayed Recognition					Score per cent	No. of Tests		
		R	Hes.		W	N		T	R	Hes.		W			N	T
			R	W						R	W					
II.	1"	6	-	-	-	4	10	60	9	-	-	1	-	10	80	1
IV.	1/5"	12	-	-	-	8	20	60	18	-	-	2	-	20	80	2
II.	1/10"	12	-	-	-	8	20	60	19	-	-	1	-	20	90	2
II.	1/25"	6	-	-	-	4	10	60	9	-	-	1	-	10	80	1
II.	1/50"	5	-	-	-	5	10	50	9	-	-	1	-	10	80	1 7

3. Delayed Recognition									
No. of Exp't	Time of Exposure	R	Hes.		W	N	T	Score per cent	No. of Tests
			R	W					
II.	1"	38	-	2	-	-	40	95	4
IV.	1/5"	20	-	-	-	-	20	100	2
II.	1/10"	29	-	-	1	-	30	93	3
II.	1/25"	19	-	-	1	-	20	90	2
II.	1/50"	27	-	-	3	-	30	80	3 14

Total tests 35

The score for delayed recognition after recall is 80 per cent for each item with the exception of exposure for 1/10" in which case the score is 90 per cent.

The results for recall are considerably lower than those for recognition. The scores are 60 per cent for exposures from 1" to 1/25", and 50 per cent for 1/50" exposure. It seems, then, that in this subject a variation in stimulation time has little effect on recall and on delayed recognition after recall.

*Experiments with Figures.* Experiment III gave the results in Table X. In immediate recognition the scores are 95, 85, 83, 80, and 80 per cent for the respective exposures from 1" to 1/50". These scores are somewhat lower than the corresponding scores for pictures, the differences for the various exposures being 0, 15, 10, 10, and 7 per cent. With decreased stimulation time the score drops somewhat less rapidly than that for pictures. An-



TABLE X

Summary of Experiments with Figures and Variation in Time of Exposure  
Subject: H-n.

1. Immediate Recognition

No. of Exp't.	Time of Exposure	R	Hes. R	W	N	T	Score per cent	No. of Tests	
III.	1"	19	—	1	—	—	20	95	2
V.	1/5"	26	1	2	1	—	30	85	3
III.	1/10"	36	—	1	3	—	40	83	4
III.	1/25"	18	—	—	2	—	20	80	2
III.	1/50"	18	—	—	2	—	20	80	2
									13

2. Delayed Recognition

III.	1"	18	—	—	2	—	20	80	2
V.	1/5"	26	—	1	3	—	30	77	3
III.	1/10"	35	—	—	5	—	40	75	4
III.	1/25"	35	—	—	5	—	40	75	4
III.	1/50"	17	—	—	3	—	20	70	2
									15

Total tests 28

other difference will be found in the fact that with figures the best results are obtained with a stimulation time of 1" as against that of 1/5" with pictures.

In delayed recognition the scores for the respective exposures are 80, 77, 75, 75, and 70 per cent. The corresponding differences between these scores and those in immediate recognition are 15, 8, 8, 5, and 10 per cent. With this material we find, therefore, a marked influence of the retention time factor on recognition. The influence of a gradual shortening of the stimulation time is less marked than was the case in immediate recognition.

Differences in results arising from emotional or interest effect of the material were not noticed in the experiments with this subject.

Subject: D-n

*Experiments with Pictures.* The results of Experiment II are found in Table XI. In immediate recognition the scores are 68, 63, 57, 30, and 15 per cent respectively for exposures from 1" to 1/50". There is an increasing decline in the scores with a gradual reduction in stimulation time, the difference between the scores for 1" and 1/50" exposure being 53 per cent.

A similar decline is found in delayed recognition, the scores

TABLE XI

*Summary of Experiments with Pictures and Variation in Time of Exposure.*  
*Subject: D-n.*

1. Immediate Recognition									
No. of Exp't	Time of Exposure						Score per cent	No. of Tests	
		R	Hes. R	W	N	T			
II.	1"	15	1	-	2	2	20	68	2
IV.	1/5"	24	-	1	5	-	30	63	3
II.	1/10"	22	-	1	5	2	30	57	3
II.	1/25"	5	-	-	2	3	10	30	1
II.	1/50"	10	-	-	7	3	20	15	2 II

2. Recall and Delayed Recognition																
No. of Exp't	Time of Expos.	Recall					Score per cent	Delayed Recognition					Score per cent	No. of Tests		
		R	Hes. R	W	N	T		R	Hes. R	W	N	T				
II.	1"	5	-	-	-	5	10	50	8	-	-	2	-	10	60	1
IV.	1/5"	19	-	-	-	11	30	63	25	-	-	5	-	30	67	3
II.	1/10"	6	-	-	-	4	10	60	6	-	-	2	2	10	40	1
II.	1/25"	5	-	-	-	5	10	50	6	-	-	4	-	10	20	1
II.	1/50"	4	-	-	-	6	10	40	4	-	-	6	-	10	-20	1 7

3. Delayed Recognition									
No. of Exp't	Time of Exposure						Score per cent	No. of Tests	
		R	Hes. R	W	N	T			
II.	1"	16	-	-	4	-	20	60	2
IV.	1/5"	23	-	1	6	-	30	57	3
II.	1/10"	27	-	-	6	7	40	53	4
II.	1/25"	6	-	-	4	-	10	20	1
II.	1/50"	7	-	-	6	7	20	5	2 12

Total tests 30

being 60, 57, 53, 20, and 5 per cent. The difference between the scores for 1" and for 1/50" exposure is 55 per cent, hence practically the same as that in immediate recognition. The differences in score between immediate and delayed recognition for the various exposures from 1" to 1/50" are 8, 6, 4, 10, and 10 per cent respectively. An interval of 3' between exposure and selection, therefore, moderately lowers the results in recognition.

The average result for delayed recognition after recall, if we except the score for 1/50" exposure, is practically the same as that for delayed recognition without recall. The difference appearing with exposure of 1/50" is not of sufficient value for drawing conclusions. It would therefore seem that the effort to recall has no noticeable effect upon delayed recognition.

The average recall score is higher than that for immediate recognition. The recall scores are 50, 63, 60, 50, and 40 per cent

for the respective exposures. The highest score is obtained with exposure for  $1/5''$ , below there is a gradual decline, less marked than in recognition. The recall memory seems, therefore, to be superior to the recognition memory with this subject.

TABLE XII

*Summary of Experiments with Figures and Variation in Time of Exposure.*  
Subject: D-n.

## 1. Immediate Recognition

No. of Exp't.	Time of Exposure	R	Hes. R	W	N	T	Score per cent	No. of Tests	
III.	1''	14	—	—	3	3	20	55	2
V.	$1/5''$	20	—	1	9	—	30	37	3
III.	$1/10''$	26	—	—	10	4	40	40	4
III.	$1/25''$	8	—	—	6	6	20	10	2
III.	$1/25''$	9	—	—	8	3	20	5	2
									13

## 2. Delayed Recognition

III.	1''	11	1	—	4	4	20	38	2
V.	$1/5''$	18	—	—	12	—	30	20	3
III.	$1/10''$	21	1	—	13	5	40	21	4
III.	$1/25''$	10	—	—	10	—	20	0	2
III.	$1/50''$	6	—	—	12	2	20	-30	2

Total tests 26

*Experiments with Figures.* The following results were obtained in Experiment III (Table XII). In immediate recognition the scores are 55, 37, 40, 10, and 5 per cent for the respective exposures. These scores are lower than the corresponding scores for pictures, the difference for the various exposures being 13, 26, 17, 20, and 10 per cent respectively. On the whole the scores decline with reduced stimulation time at a rate similar with that for pictures.

In delayed recognition the scores for the respective exposures are 38, 20, 21, 0, and -30 per cent. The differences between immediate and delayed recognition for the various exposures from  $1''$  to  $1/50''$  are 17, 17, 19, 10, and 35 per cent. These differences are considerably larger than the corresponding differences for pictures, hence an interval of 3' between exposure and selection reduces the results in recognition more with figures than with pictures.

A slight influence of emotional connotation in the material was noticed in experiments with pictures, those of children making a particular appeal to the subject.

## 2. VARIATION IN NUMBER OF CARDS

*Subject: McG*

*Experiments with Pictures.* The results in Experiment IV are shown in Table XIII. In immediate recognition the scores are

TABLE XIII

*Summary of Experiments with Pictures and Variation in Number of Cards.*  
*Subject: McG.*

1. Immediate Recognition													
No. of Exp't	No. of Cards	R					Score per cent	No. of Tests					
		Hes. R	W	N	T								
IV.	3	5	-	-	1	-	67	2					
IV.	5	21	-	-	4	-	68	5					
IV.	7	16	-	-	5	-	52	3					
IV.	9	13	-	-	5	-	44	2 12					

2. Recall and Delayed Recognition															
No. of Exp't	No. of Cards	Recall					Score per cent	Delayed Recognition					Score per cent	No. of Tests	
		R	Hes. R	W	N	T		R	Hes. R	W	N	T			
IV.	3	3	-	-	-	3	100	2	-	-	1	-	3	33	1
IV.	5	8	-	-	-	12 20	40	16	-	-	4	-	20	60	4
IV.	7	5	-	-	-	9 14	36	9	-	-	5	-	14	29	2
IV.	9	4	-	-	-	3 11 18	22	10	-	-	8	-	18	22	2 9

3. Delayed Recognition													
No. of Exp't	No. of Cards	R					Score per cent	No. of Tests					
		Hes. R	W	N	T								
IV.	3	4	-	2	-	-	6	33	2				
IV.	5	16	-	2	7	-	25	36	5				
IV.	7	13	-	-	8	-	21	24	3				
IV.	9	9	1	-	8	-	18	8	2 12				

Total tests 33

67, 68, 52, and 44 per cent for exposures of 3, 5, 7, and 9 cards respectively. Slightly better results are obtained with 5 than with 3 cards. With more than 5 cards the results show a gradual decline.

In delayed recognition the results are considerably lower, the corresponding scores being 33, 36, 24, and 8 per cent. We find the following differences between the two series of scores: 34, 32, 28, and 36 per cent. The greatest difference appears for the 9-card set and the smallest for the 7-card set, with a gradual increase towards the smaller sets.

In delayed recognition after recall the results are better than

in delayed recognition without recall, the scores being 33, 60, 29, and 22 per cent for the respective sets of cards. This was not generally the case in Exp. II, and the difference may be due to the fact that Exp. IV occurs in the middle of the series and is therefore preceded by a period of training. The figures in Table V for exposure of 1/5", which are the only ones to show this tendency in that table, are largely taken from Exp. IV.

The recall scores are 100, 40, 36, and 22 per cent for the respective sets of cards. Hence the recall memory is perfect for 3 cards and superior to the recognition memory for the same number of items, but with an increased number of cards it is inferior to the recognition memory.

*Experiments with Figures.* Table XIV shows the results in

TABLE XIV

*Summary of Experiments with Figures, and Variation in Number of Cards.*  
 Subject: McG.

1. Immediate Recognition

No. of Exp't	No. of Cards	R	Hes. R	W	N	T	Score per cent	No. of Tests
V.	3	4	-	-	2	-	33	2
V.	5	19	-	-	11	-	27	6
V.	7	15	-	-	13	-	7	4
V.	9	18	-	-	18	-	0	4
								16

2. Delayed Recognition

V.	3	4	-	-	2	-	33	2
V.	5	17	-	-	13	-	13	6
V.	7	13	-	-	15	-	-7	4
V.	9	18	-	-	18	-	0	4
								16

Total tests 32

experiments with figures. The immediate recognition scores are 33, 27, 7, and 0 per cent for sets of 3, 5, 7, and 9 cards respectively. These scores are lower and decline more rapidly than those for pictures, the differences for the four sets being 34, 41, 45, and 44 per cent respectively. The slight advantage of the 5-card set over that of 3 cards with pictures does not obtain with figures.

In delayed recognition the scores are 33, 13, -7, and 0 per cent for the respective sets of cards. The corresponding differences from the immediate recognition scores are 0, 14, 14, and 0 per

cent; they are considerably smaller and less evenly distributed than those for pictures.

We may conclude that the subject is able to take in a set of 3 pictures sufficiently well for immediate recall, but is unable to take in enough characteristics of the same number of items of either material to distinguish them well from similar pictures or figures. With an increase in the number of items to the set, however, the results for recall become inferior to those for recognition.

TABLE XV  
*Summary of Experiments with Pictures and Variation in Number of Cards.*  
Subject: E-n.

		1. Immediate Recognition							Score	No. of					
No. of	No. of	R	Hes.	W	N	T		per cent	Tests						
Exp't	Cards		R	W											
IV.	3	4	-	-	2	-	6	33	2						
IV.	5	17	1	-	6	1	25	46	5						
IV.	7	14	-	-	7	-	21	33	3						
IV.	9	12	-	-	6	-	18	33	2 12						
		2. Recall and Delayed Recognition													
Exp't	Cards	Recall					Delayed Recognition					Score	No. of		
		No. of	R	Hes.	W	N	T	Score	R	Hes.	W			N	T
			R	R	W			per cent	R	R	W				
IV.	3	1	-	-	-	2	3	33	3	-	-	-	3	100	1
IV.	5	4	-	-	-	16	20	20	9	-	-	8	3	20	5
IV.	7	3	-	-	-	11	14	21	7	-	1	5	1	14	2
IV.	9	2	-	-	-	16	18	11	11	1	-	6	-	18	31
		3. Delayed Recognition													
No. of	No. of	R	Hes.	W	N	T	Score	No. of							
Exp't	Cards		R	W			per cent	Tests							
IV.	3	3	-	-	3	-	0	2							
IV.	5	16	-	-	9	-	28	5							
IV.	7	11	-	-	10	-	5	3							
IV.	9	9	-	-	9	-	0	2 12							
Total tests 33															

Subject: E-n

*Experiments with Pictures.* Table XV shows the results in Experiment IV. The scores for immediate recognition are 33, 46, 33, and 33 per cent for the corresponding sets of 3, 5, 7, and 9 cards. The score for 5 cards is superior to that for 3 items, and with 7 and 9 cards to the set the scores are the same as for the 3-card set.

In delayed recognition the scores are 0, 28, 5, and 0 per cent for the corresponding sets. The differences for the four sets between the scores in delayed and in immediate recognition are 33, 18, 28, and 33 per cent respectively. The result for the 3-card set is rather confusing and should probably be ascribed to an occasionally recurring "absent-mindedness" in the subject, observed in these experiments. The remaining delayed recognition scores differ from the immediate recognition scores at a rate increasing with the number of cards to the set.

In delayed recognition after recall the scores are 100, 5, 14, and 31 per cent respectively. The high score for the 3-card set may possibly be ascribed to a tendency opposite to that recorded in connection with delayed recognition without recall and observed in the experiment. Occasionally, although rarely, the subject would make a rapid selection, being very positive about the results which then usually were correct. The remaining scores show a gradual increase, not found in the scores for immediate recognition, delayed recognition without recall, and recall.

The recall scores are 33, 20, 21, and 11 per cent for the respective sets of cards. With exception of the almost equal scores for 5- and 7-card sets, the scores decline gradually with an increase in items to the set. For 3-card sets the score equals the immediate recognition score, for larger sets it is inferior to the latter.

TABLE XVI

*Summary of Experiments with Figures and Variation in Number of Cards.*

*Subject: E n.*

No. of Exp't	No. of Cards	R	Hes. R	W	N	T	Score per cent	No. of Tests
1. <i>Immediate Recognition</i>								
V.	3	4	-	-	2	-	33	2
V.	5	23	-	-	7	-	53	6
V.	7	19	-	-	9	-	34	4
V.	9	22	-	-	14	-	22	4 16
2. <i>Delayed Recognition</i>								
V.	3	4	-	-	2	-	33	2
V.	5	19	1	-	10	-	32	6
V.	7	18	-	-	10	-	29	4
V.	9	21	-	-	15	-	17	4 16

Total tests 32

*Experiments with Figures.* Table XVI gives the results in Experiment V. The immediate recognition scores are 33, 53, 34, and 22 per cent for the four sets of cards respectively. Of these the scores for 3- and 7-card sets are identical or almost identical with, those for 5-card sets higher, and those for 3-card sets lower than the corresponding picture scores.

In delayed recognition the scores are 33, 32, 29, and 17 per cent, thus showing a gradually increasing decline with an increasing number of items to the set. We find the following differences between the scores in delayed and in immediate recognition for the four sets respectively: 0, 21, 5, and 5 per cent.

*Subject: H-n*

*Experiments with Pictures.* The results obtained in Experiment IV are shown in Table XVII. In immediate recognition the scores are 100 per cent for sets up to and including 15 items and 90 per cent for 20 items.

TABLE XVII

*Summary of Experiments with Pictures and Variation in Number of Cards.*  
*Subject: H-n.*

No. of Exp't	No. of Cards	I. Immediate Recognition					Score per cent	No. of Tests
		R	Hes. R	W	N	T		
IV.	5	5	-	-	-	5	100	1
IV.	10	20	-	-	-	20	100	2
IV.	15	15	-	-	-	15	100	1
IV.	20	19	-	-	1	20	90	1 5

No. of Exp't	No. of Cards	2. Recall and Delayed Recognition					Score per cent	Delayed Recognition					Score per cent	No. of Tests	
		R	Hes. R	W	N	T		R	Hes. R	W	N	T			
IV.	5	9	-	-	-	1 10	90	10	-	-	-	-	10	100	2
IV.	10	12	-	-	-	8 20	60	18	-	-	2	-	20	80	2
IV.	15	14	-	-	-	16 30	47	28	-	-	2	-	30	87	2
IV.	20	13	-	-	-	7 20	65	19	-	-	1	-	20	90	1 7

No. of Exp't	No. of Cards	3. Delayed Recognition					Score per cent	No. of Tests
		R	Hes. R	W	N	T		
IV.	5	5	-	-	-	5	100	1
IV.	10	20	-	-	-	20	100	2
IV.	15	13	1	-	1	15	83	1
IV.	20	18	-	-	2	20	80	1 5

Total tests 17



In delayed recognition the scores are 100, 100, 83, and 80 per cent for sets of 5, 10, 15, and 20 cards respectively. The differences between the scores in delayed and in immediate recognition are for the four sets respectively: 0, 0, 17, and 10 per cent.

In delayed recognition after recall the scores are 100, 80, 87, and 90 per cent for the respective sets of cards. Comparing these scores with those in delayed recognition without recall we find them equal for 5-card sets; for 10-card sets the former are inferior, and for 15- and 20-card sets increasingly superior. The former scores shows a tendency to rise, the latter to decline with an increase in items beyond 10 to the set.

The recall scores are 90, 60, 47, and 65 per cent for the respective sets. They are inferior to the corresponding scores in immediate recognition, the differences being 10, 40, 53, and 25 per cent respectively. We note a general tendency to decline with an increase in items to the set and an exception to this tendency in the results for 20-card sets. This final rise in the score shows a tendency similar to that found in the scores for delayed recognition after recall.

*Experiments with Figures.* Table XVIII shows the results in

TABLE XVIII

*Summary of Experiments with Figures and Variation in Number of Cards.*  
*Subject: H-n.*

No. of Exp't	No. of Cards	1. Immediate Recognition						Score per cent	No. of Tests
		R	Hes. R	Hes. W	W	N	T		
V.	5	18	—	1	1	—	20	85	4
V.	10	26	1	2	1	—	30	85	3
V.	15	27	—	—	3	—	30	80	2
V.	20	16	—	—	4	—	20	60	1 10
2. Delayed Recognition									
V.	5	17	—	1	2	—	20	75	4
V.	10	26	—	1	3	—	30	77	3
V.	15	26	—	1	3	—	30	77	2
V.	20	15	—	—	5	—	20	50	1 10
								Total tests 20	

Experiment V. The immediate recognition scores are 85, 85, 80, and 60 per cent for the respective sets of cards. They are considerably lower and decline more rapidly than the correspond-

ing scores for pictures, the differences for the four sets respectively being 15, 15, 20, and 30 per cent.

In delayed recognition the scores are 75, 77, 77, and 50 per cent for the respective sets of cards. We note the slight inferiority of the score for 5-card sets to that for 10- and 15-card sets, not found elsewhere with this subject. The differences between the scores in delayed and in immediate recognition for the four sets respectively are 10, 8, 3, and 10 per cent. The average difference for figures is slightly in excess of that for pictures. We note that with pictures the difference is greatest for 15-card sets and absent for 5- and 10-card sets, whereas with figures the greatest differences appear for 5- and 20-card sets and the smallest for 15-card sets.

*Subject: D-n*

*Experiments with Pictures.* Table XIX gives the results in

TABLE XIX

*Summary of Experiments with Pictures and Variation in Number of Cards.*  
*Subject: D-n.*

<i>1. Immediate Recognition</i>										
No. of Exp't	No. of Cards	R					Score per cent	No. of Tests		
		R	Hes. R W	W	N	T				
IV.	5	4	- -	1	-	5	60	1		
IV.	10	24	- 1	5	-	30	63	3		
IV.	15	24	- 1	5	-	30	63	2		
IV.	20	16	- -	4	-	20	60	1 7		

<i>2. Recall and Delayed Recognition</i>															
No. of Exp't	No. of Cards	Recall						Score per cent	Delayed Recognition					Score per cent	No. of Tests
		R	Hes. R W	W	N	T	R		Hes. R W	W	N	T			
IV.	5	7	- - -	3	10	70	9	- -	1	-	10	80	2		
IV.	10	19	- - -	11	30	63	25	- -	5	-	30	67	3		
IV.	15	12	- - -	18	30	40	24	- -	6	-	30	60	2		
IV.	20	7	- - -	13	20	35	15	- -	5	-	20	50	1 8		

<i>3. Delayed Recognition</i>										
No. of Exp't	No. of Cards	R					Score per cent	No. of Tests		
		R	Hes. R W	W	N	T				
IV.	5	4	- -	1	-	5	60	1		
IV.	10	23	- 1	6	-	30	57	3		
IV.	15	19	- -	11	-	30	27	2		
IV.	20	12	1 -	7	-	20	28	1 7		

Total tests 22

Experiment IV. The immediate recognition scores are 60, 63, 63, and 60 per cent for sets of 5, 10, 15, and 20 cards respectively. There is little variation between the scores, which would indicate that about the same proportion of items is taken in for small as for large sets.

In delayed recognition the scores are 60, 57, 27, and 28 per cent for the respective sets of cards. The differences between the scores in delayed and in immediate recognition for the four sets respectively are 0, 6, 36, and 32 per cent. It would therefore seem that an increase in items beyond 10 to the set greatly reduces retention.

In delayed recognition after recall the scores are 80, 67, 60, and 50 per cent. They are higher throughout and show slightly less decline than those for delayed recognition without recall. The scores for the two smaller sets are higher, those for the two larger sets lower than the corresponding scores for immediate recognition.

The recall scores are 70, 63, 40, and 35 per cent for the respective sets of cards. For 5-card sets the score is higher than, for 10-card sets equal to, and for 15- and 20-card sets lower than that for immediate recognition. The sharpest decline occurs with 15-card sets.

*Experiments with Figures.* Table XX gives the results obtained in Experiment V. In immediate recognition the scores

TABLE XX

*Summary of Experiments with Figures and Variation in Number of Cards*  
Subject: D-n.

No. of Exp't	No. of Cards	1. Immediate Recognition					Score per cent	No. of Tests	
		R	Hes. R	W	N	T			
V.	5	13	—	—	7	—	20	30	4
V.	10	20	—	1	9	—	30	37	3
V.	15	19	—	—	11	—	30	27	2
V.	20	12	—	—	8	—	20	20	1 10
2. Delayed Recognition									
V.	5	11	—	—	8	—	20	20	4
V.	10	18	—	—	12	—	30	20	3
V.	15	15	—	—	15	—	30	0	2
V.	20	10	—	—	10	—	20	0	1 10
								Total tests	20

are 30, 37, 27, and 20 per cent for the respective sets of cards. They are much lower and decline more markedly than the corresponding scores for pictures, the differences for the four sets respectively being 30, 26, 36, and 40 per cent. As with pictures, the score for 5-card sets is slightly inferior to that for 10-card sets.

In delayed recognition the scores are 20, 20, 0, and 0 per cent for the respective sets of cards. The differences between these scores and those for immediate recognition are 10, 17, 27, and 20 per cent respectively, showing the same deterioration in retention with large sets of cards as was found in the scores for pictures.

Figures 3 to 10, pp. 49-52, represent the results obtained in Experiments II to V.

### 3. COLORED PICTURES

The experiments with colored pictures (Exp. I and VI) were made partly to accustom the subjects to the method of experimentation, partly for the purpose of ascertaining whether a prolonged period of experimentation had changed the condition of the subjects' memory. The results are given in Table XXI.

TABLE XXI

*Experiments with Colored Pictures.*

Subjects	The first six columns give per cent score.		Immediate Recall		Delayed Recog.		Interval between experiments.
	Exp. I	Exp. VI	Exp. I	Exp. VI	Exp. I	Exp. VI	
Mc.G.	28	28	60	56	28	12	- days -
E-n.	36	72	16	20	12	4	30
H-n.	60	100	30	56	60	90	47
D-n.	60	64	55	52	35	62	32
							27

*H-n* has considerably higher results in Exp. VI than in Exp. I, due probably to the training received in the experimentation. The interval between exposure and selection did not change the results in Exp. I, but a slight change is found in Exp. VI. If we assume that an improvement has taken place, it is probably in the subject's apprehension. *E-n* shows a similar improvement in apprehension, although his results for delayed recognition in Exp. VI are inferior to those in Exp. I. The slightly higher

results of *D-n* for recognition in Exp. VI over those in Exp. I are probably sufficiently explained by an increased familiarity with the experiment. She shows no improvement in recall. The reduced results of *McG* for recall and for delayed recognition in Exp. VI may be interpreted to indicate at least that no improvement has taken place.

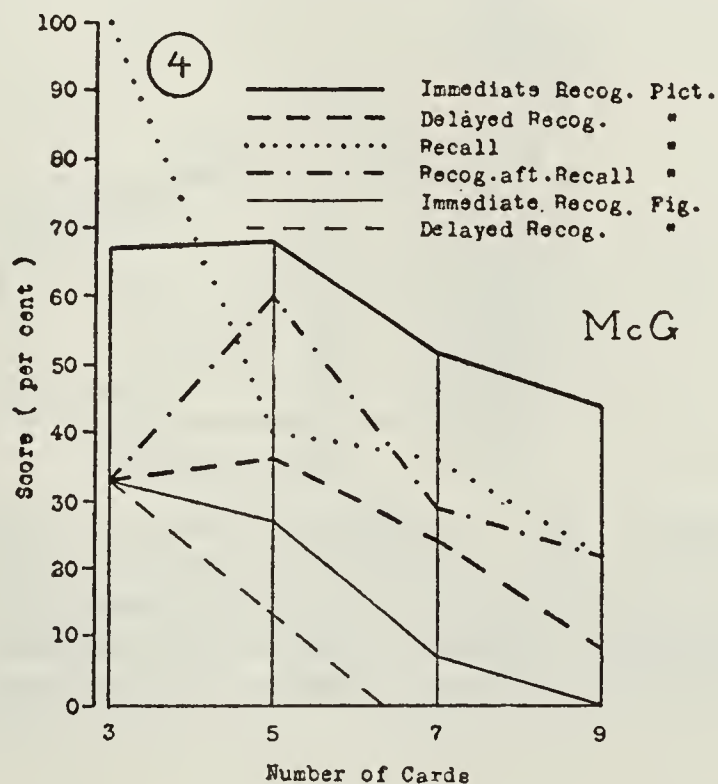
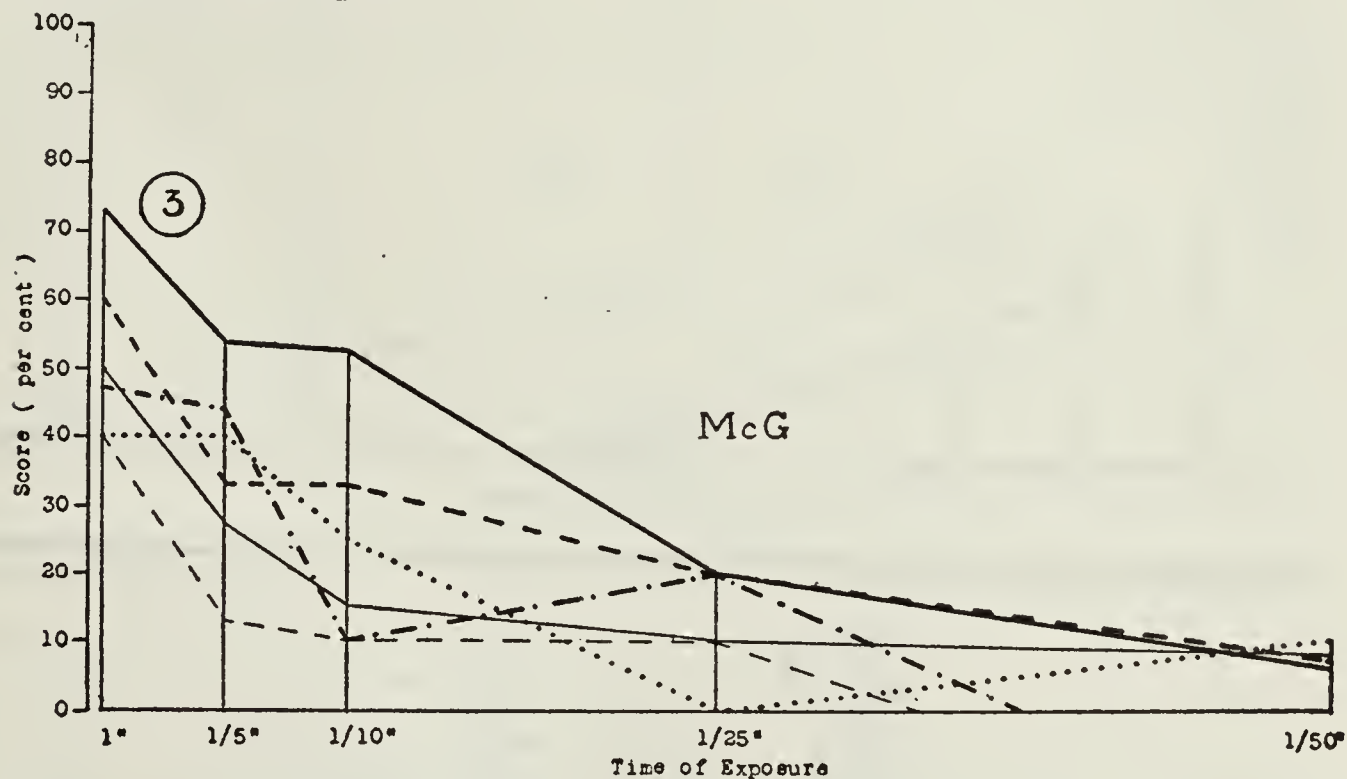


Fig. 3.—Subject: McG. Variation in Time of Exposure.

FIG. 4.—Subject: McG. Variation in Number of Cards.

Both figures give the results in immediate recognition, delayed recognition, recall, and delayed recognition after recall with pictures, and in immediate and in delayed recognition with figures. Per cent score.

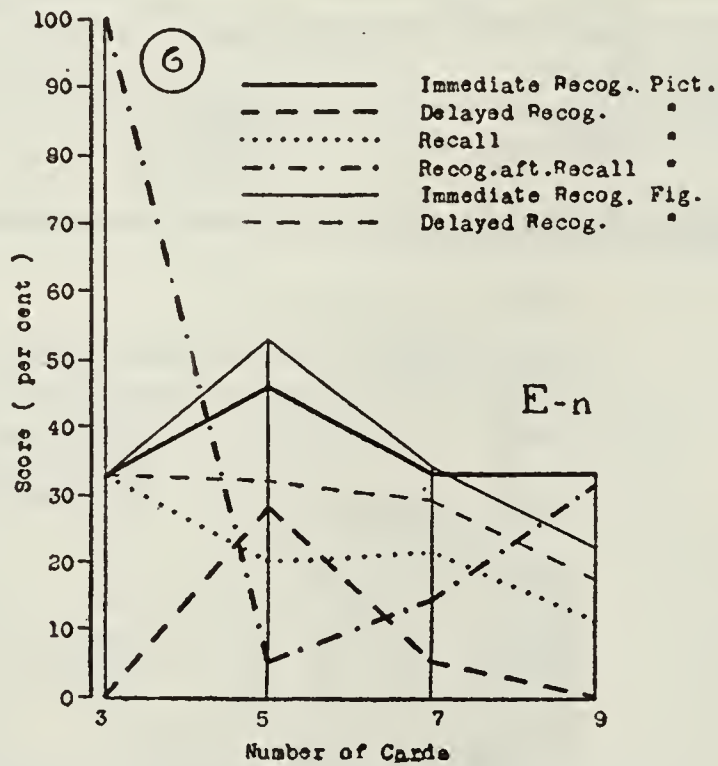
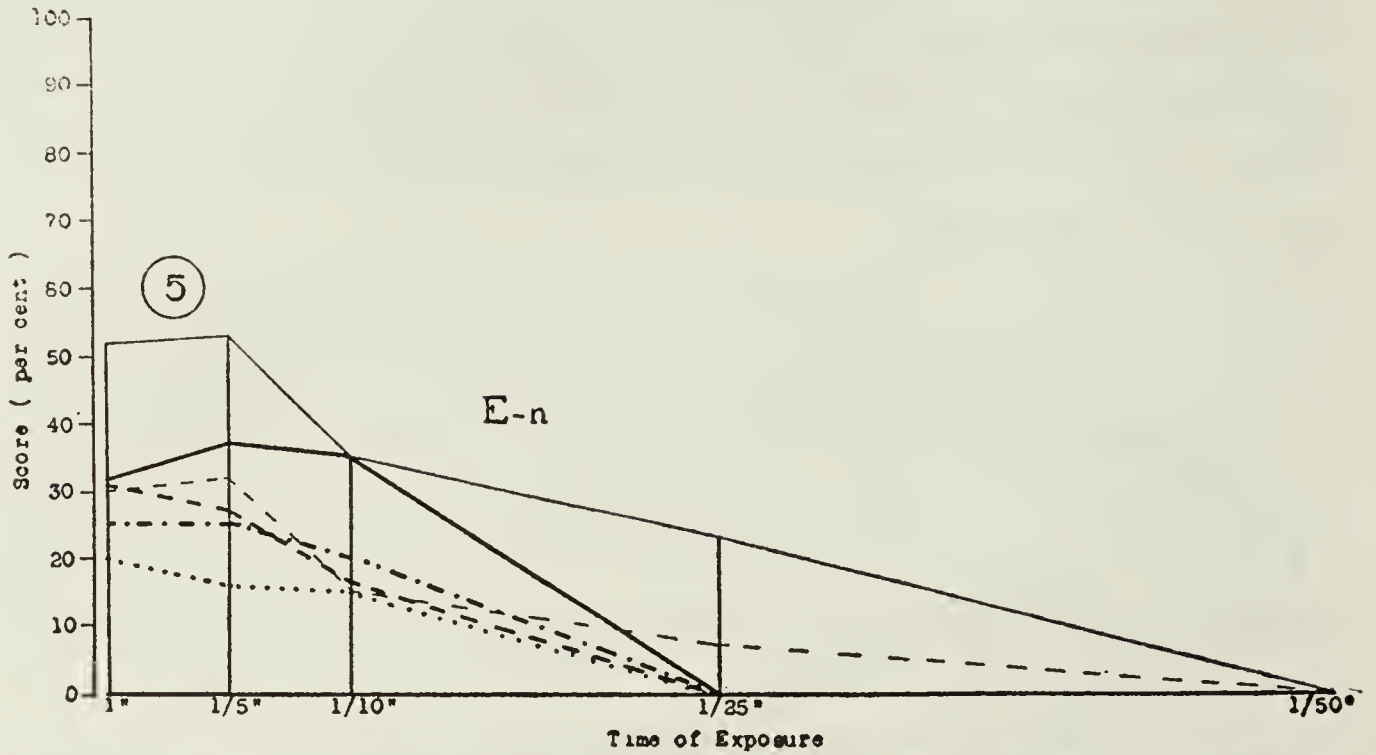


FIG. 5.—Subject: E-n. Variation in Time of Exposure.

FIG. 6.—Subject: E-n. Variation in Number of Cards.

Both figures give the results in immediate recognition, delayed recognition, recall, and delayed recognition after recall with pictures, and in immediate and in delayed recognition with figures. Per cent score.

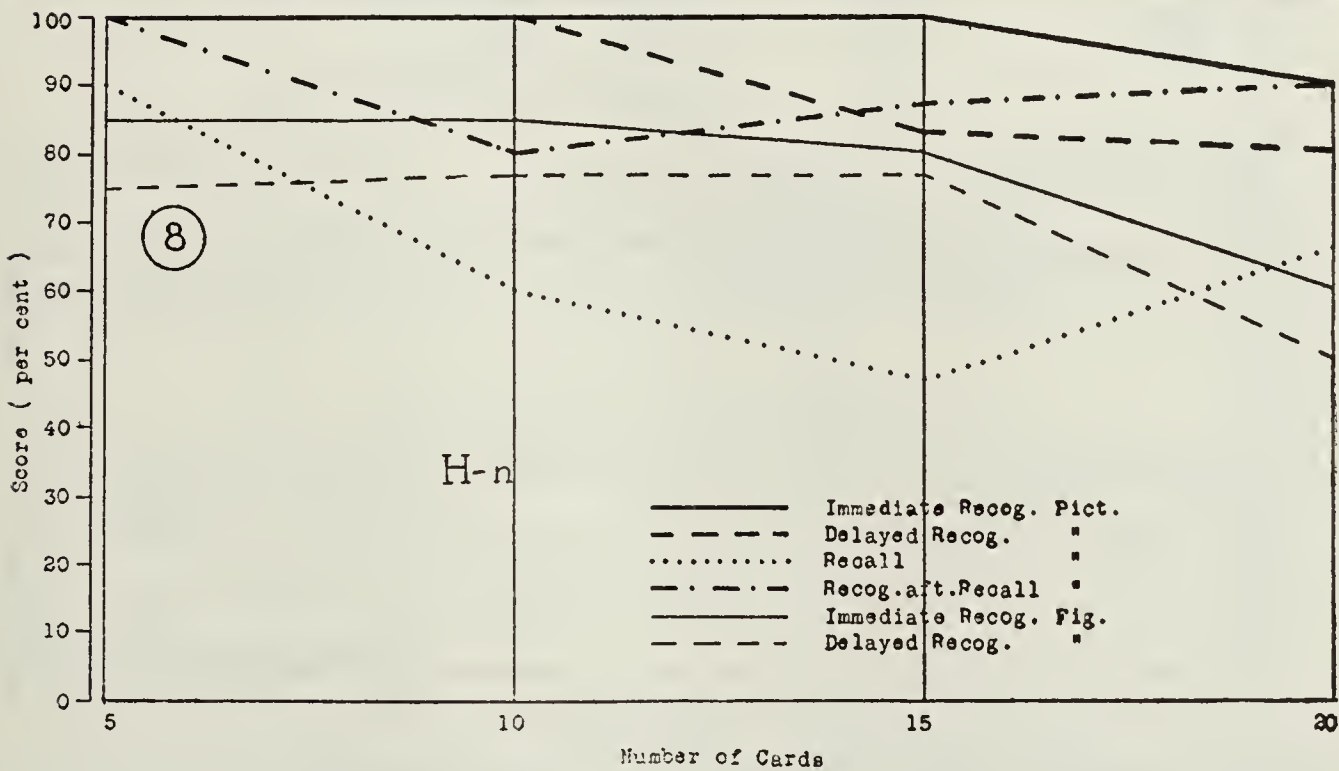
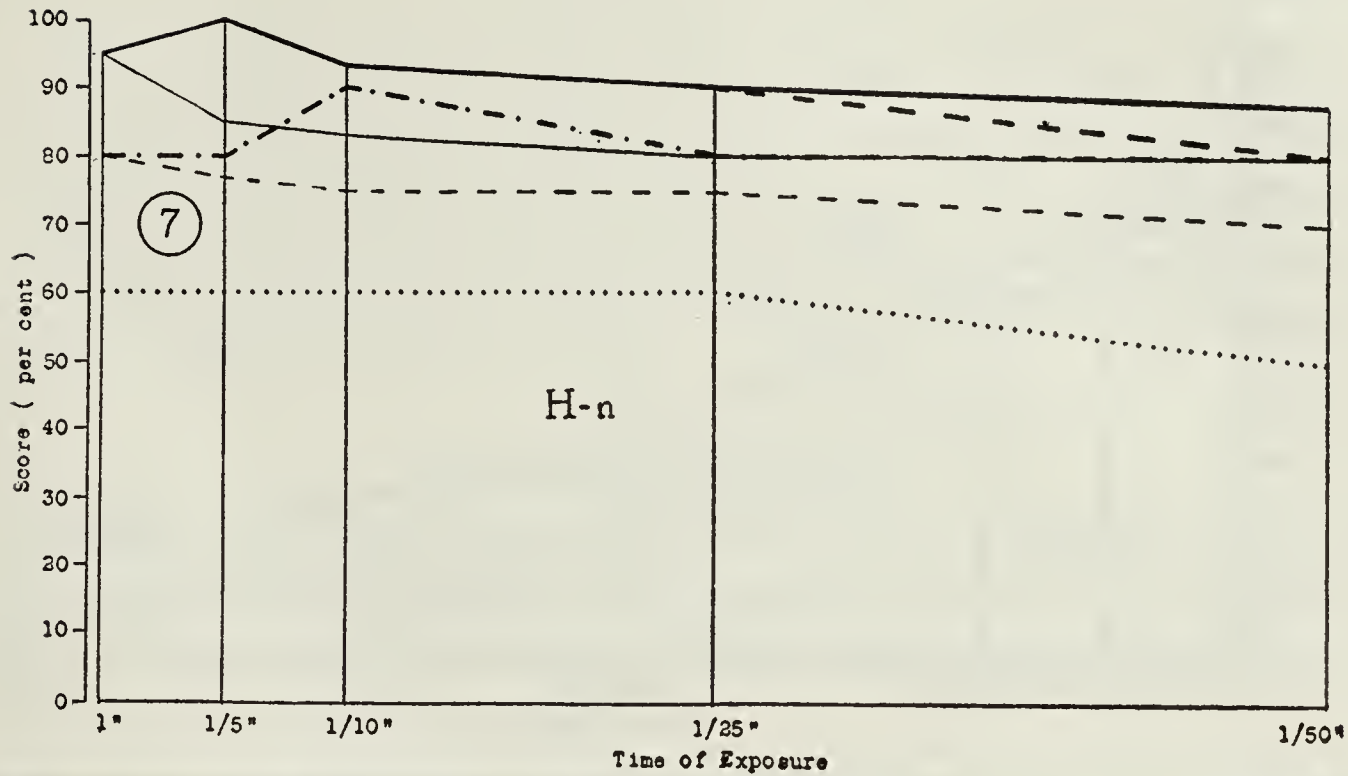


FIG. 7.—Subject: H-n. Variation in Time of Exposure.

FIG. 8.—Subject: H-n. Variation in Number of Cards.

Both figures give the results in immediate recognition, delayed recognition, recall, and delayed recognition after recall with pictures, and in immediate and in delayed recognition with figures. Per cent score.

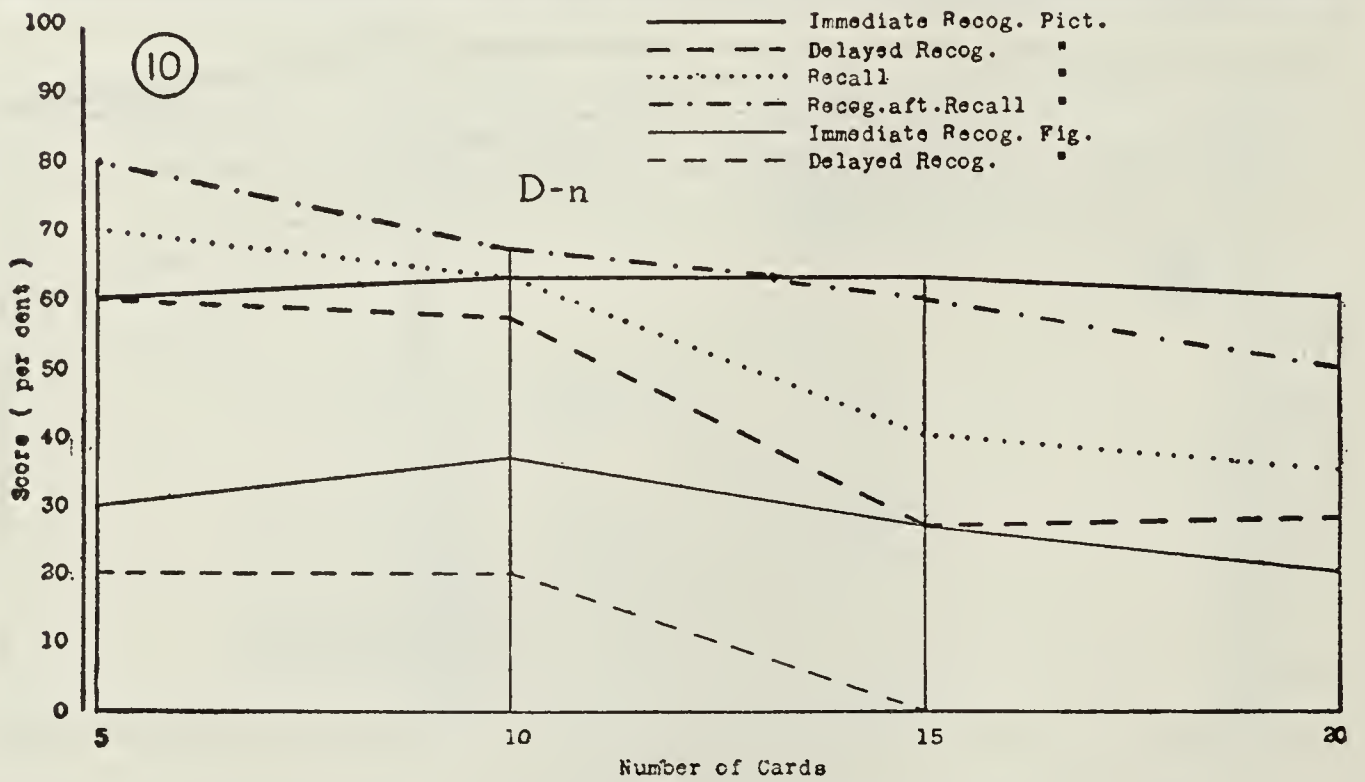
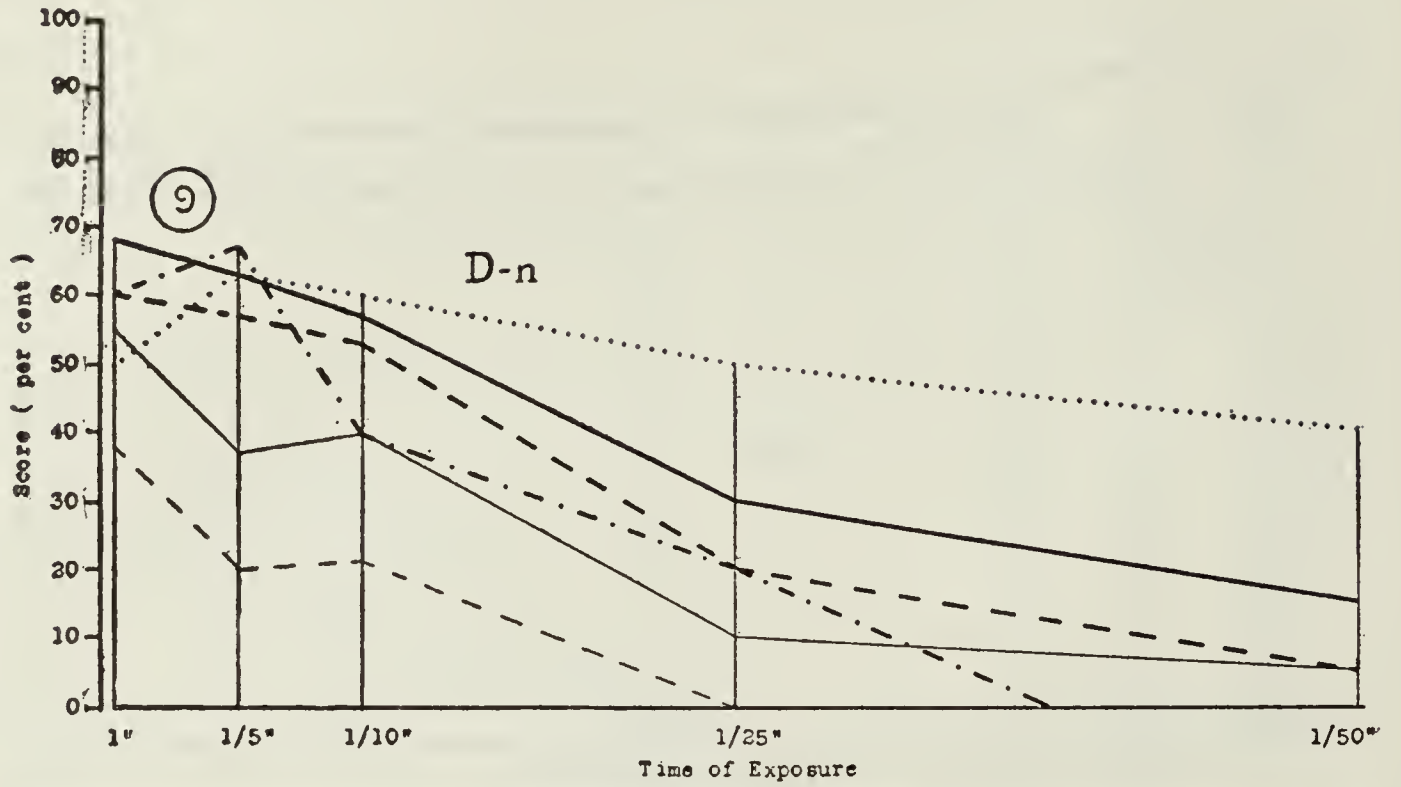


FIG. 9.—Subject: D-n. Variation in Time of Exposure.

Fig. 10.—Subject: D-n. Variation in Number of Cards.

Both figures give the results in immediate recognition, delayed recognition, recall, and delayed recognition after recall with pictures, and in immediate and in delayed recognition with figures. Per cent score.



## 4. REPEATED AND INTERVENING STIMULI

## A. Repeated Stimuli

The results in Experiment VII (Tables XXII and XXIII) show that with *H-n* a second exposure of the cards improves the results; subsequent exposures seem to have little or no effect. With *D-n* each of the four repetitions increases the results; the greatest increases occur with the second and the fourth repetitions.

## B. Intervening Stimuli

Tables XXIV and XXV give the results in Experiment VIII. Comparing these with the corresponding results in Experiment VII (Tables XXII and XXIII) we find the following differences between the respective scores:

<i>Presentations</i>	<i>H-n</i>	<i>D-n</i>
1.	37%	23%
2.	33%	22%
3.	34%	5%
4.	26%	18%

In both subjects the intervening stimulation interferes with recall memory, but this interference decreases with a continued repetition of both primary and secondary stimuli.

## 5. PRIMACY AND RECENCY

Tables XXVI-XXIX show the distribution of correct selections in relation to the order of exposure of the cards. They include only the results of experiments with the "normal" sets of 5 and 10 cards respectively.

*McG.* In immediate recognition of pictures the last two cards are most frequently selected, the first and the third least frequently. In delayed recognition of pictures the third and the last are most frequently, the first less frequently selected. In immediate recognition of figures the last card is most frequently selected, next in order of frequency the third, and last the first with the fourth card a close second. In delayed recognition of figures the variation is very insignificant. With this subject recency therefore influences selection favorably in immediate recognition, both

TABLE XXII

*Experiments with Pictures. Four successive tests in which each picture is exposed for 1/5". In the first test a set of 7 pictures is presented, to which is added 1 picture for each succeeding test. Recall 2 minutes after each presentation. Five experiments with four tests each.*

Subject: H-n

Test no.	Selections			Score
	R	W	T	Per cent
1.	32	—	35	91
2.	39	—	40	98
3.	44	—	45	98
4.	48	—	50	96

TABLE XXIII

*Experiments with Pictures. Four successive tests in which each picture is exposed for 1/5". In the first test a set of 7 pictures is presented, to which is added 1 picture for each succeeding test. Recall 2 minutes after each presentation. Five experiments with four tests each.*

Subject: D-n

Test no.	Selections			Score
	R	W	T	Per cent
1.	20	—	35	57
2.	30	—	40	75
3.	34	—	45	76
4.	44	—	50	88

TABLE XXIV

*Experiments with Pictures. Four successive tests in which each picture is exposed for 1/5". In the first test a set of 7 pictures is presented, to which is added 1 picture for each succeeding test. Each test is followed with an interval of 30" by a secondary test with Colored Pictures arranged and exposed as the pictures in the primary test. Recall 2 minutes after each presentation in the primary test. Five experiments with four double tests each.*

Subject: H-n

Test no.	Selections			Score
	R	W	T	Per cent
1.	24	5	35	54
2.	33	7	40	65
3.	33	4	45	64
4.	41	6	50	70

TABLE XXV

*Experiments with Pictures. Four successive tests in which each picture is exposed for 1/5". In the first test a set of 7 pictures is presented, to which is added 1 picture for each succeeding test. Each test is followed with an interval of 30" by a secondary test with Colored Pictures arranged and exposed as the pictures in the primary test. Recall 2 minutes after each presentation in the primary test. Five experiments with four double tests each.*

Subject: D-n

Test no.	Selections			Score
	R	W	T	Per cent
1.	12	—	35	34
2.	21	—	40	53
3.	32	—	45	71
4.	35	—	50	70

TABLE XXVI

*Distribution of Selections*

Computed from experiments with pictures (P) and figures (F) in which 5 cards are exposed in succession.

*Recognition (Rg) and Retention (Rt).*

*Subject: McG*

Order of Expos.	Order of Selection															Tot.		Tot.	
	P	1st		P	2d		P	3d		P	4th		P	5th		P	F		
1st	Rg	2	2	4	4	2	6	6	2	8	1	2	3	3	2	5	16	10	26
	Rt	8	3	11	1	3	4	4	2	6	1	5	6	2	2	4	16	15	31
T	10	5	15	5	5	10	10	4	14	2	7	9	5	4	9	32	25	57	
2d	Rg	3	-	3	8	6	14	1	3	4	3	3	6	5	2	7	20	14	34
	Rt	2	4	6	5	-	5	1	4	5	8	3	11	3	3	6	19	14	33
T	5	4	9	13	6	19	2	7	9	11	6	17	8	5	13	39	28	67	
3d	Rg	1	-	1	5	6	11	3	4	7	5	4	9	3	5	8	17	19	36
	Rt	5	5	10	2	3	5	4	2	6	5	1	6	5	3	8	21	14	35
T	6	5	11	7	9	16	7	6	13	10	5	15	8	8	16	38	33	71	
4th	Rg	1	-	1	6	3	9	7	4	11	5	1	6	6	4	10	25	12	37
	Rt	2	2	4	8	3	11	4	2	6	1	7	8	4	1	5	19	15	34
T	3	2	5	14	6	20	11	6	17	6	8	14	10	5	15	44	27	71	
5th	Rg	17	20	37	3	1	4	3	-	3	1	3	4	2	-	2	26	24	50
	Rt	10	4	14	2	5	7	2	4	6	3	1	4	3	-	3	20	14	34
T	27	24	51	5	6	11	5	4	9	4	4	8	5	-	5	46	38	84	
Tot.	Rg	24	22	46	26	18	44	20	13	33	15	13	28	19	13	32	104	79	183
	Rt	27	18	45	18	14	32	15	14	29	18	17	35	17	9	26	95	72	167
Total	51	40	91	44	32	76	35	27	62	33	30	63	36	22	58	199	151	350	

Order of Expos.	Selections												Total	
	Rg	Pictures				T	Rg	Figures				T	Total	
		pc	Rt		pc			pc	Rt		pc			
1st	16	53	16	53	32	53	10	38	15	58	25	48	57	51
2d	20	67	19	63	39	65	14	54	14	54	28	54	67	60
3d	17	57	21	70	38	64	19	73	14	54	33	64	71	63
4th	25	83	19	63	44	73	12	46	15	58	27	52	71	63
5th	26	87	20	67	46	77	24	92	14	54	38	73	84	75
Total	104		95		199		79		72		151		350	
Total	pc	69	63		66		61		55		58		62	

Total Pictures exposed: Rg. 150 — Rt. 150 — total 300  
 Total Figures exposed: Rg. 130 — Rt. 130 — total 260  
 Total Cards exposed: Rg. 280 — Rt. 280 — total 560  
 Total Pictures selected: Rg. 104 — Rt. 95 — total 199  
 Total Figures selected: Rg. 79 — Rt. 72 — total 151  
 Total Cards selected: Rg. 183 — Rt. 167 — total 350

TABLE XXVII  
Distribution of Selections

Computed from experiments with pictures (P) and figures (F) in which 5 cards are exposed in succession.

Recognition (Rg) and Retention (Rt)

Subject: E-n

Order of Selection

Order of Expos.	1st			2d			3d			4th			5th			Tot.		Tot.	
	P	F	T	P	F	T	P	F	T	P	F	T	P	F	T	P	F		
1st	Rg	3	1	4	4	2	6	4	5	9	1	5	6	7	6	13	19	19	38
	Rt	4	1	5	2	2	4	2	3	5	2	4	6	3	5	8	13	15	28
	T	7	2	9	6	4	10	6	8	14	3	9	12	10	11	21	32	34	66
2d	Rg	4	-	4	6	10	16	4	3	7	5	2	7	-	-	-	19	15	34
	Rt	3	3	6	2	7	9	4	2	6	2	3	5	2	1	3	13	16	29
	T	7	3	10	8	17	25	8	5	13	7	5	12	2	1	3	32	31	63
3d	Rg	4	1	5	3	5	8	4	2	6	5	3	8	2	5	7	18	16	34
	Rt	3	2	5	2	6	8	4	3	7	3	2	5	3	1	4	15	14	29
	T	7	3	10	5	11	16	8	5	13	8	5	13	5	6	11	33	30	63
4th	Rg	1	3	4	3	3	6	5	3	8	4	5	9	3	2	5	16	16	32
	Rt	5	3	8	2	3	5	4	4	8	4	1	5	1	4	5	16	15	31
	T	6	6	12	5	6	11	9	7	16	8	6	14	4	6	10	32	31	63
5th	Rg	14	18	32	4	-	4	3	2	5	2	1	3	1	1	2	24	22	46
	Rt	6	5	11	4	-	4	1	3	4	3	5	8	2	2	4	16	15	31
	T	20	23	43	8	-	8	4	5	9	5	6	11	3	3	6	40	37	77
Tot.	Rg	26	23	49	20	20	40	20	15	35	17	16	33	13	14	27	96	88	184
	Rt	21	14	35	12	18	30	15	15	30	14	15	29	11	13	24	73	75	148
Total		47	37	84	32	38	70	35	30	65	31	31	62	24	27	51	169	163	332

Order of Expos.	Selections												Total	
	Pictures			Figures			T							
	Rg	Rt	T	Rg	Rt	T	Rg	Rt	pc	pc	pc	pc		
1st	19	63	32	19	73	34	15	58	66	59				
2d	19	63	32	15	58	31	16	62	63	56				
3d	18	60	33	16	62	50	14	54	63	56				
4th	16	53	32	16	62	31	15	58	63	56				
5th	24	80	40	22	85	37	15	58	77	69				
Total	96		169	88		163			332					
Tot. pc		62		68		63		60		60				

Total Pictures exposed: Rg. 150 — Rt. 150 — total 300  
 Total Figures exposed: Rg. 130 — Rt. 130 — total 260  
 Total Cards exposed: Rg. 280 — Rt. 280 — total 560

Total Pictures selected: Rg. 96 — Rt. 73 — total 169  
 Total Figures selected: Rg. 88 — Rt. 75 — total 163  
 Total Cards selected: Rg. 184 — Rt. 148 — total 332

TABLE XXVIII

Distribution of Selections

Computed from experiments with pictures (P) and figures (F) in which 10 cards are exposed in succession.  
Recognition (Rg) and Retention (Rt).  
Subject: H-n

Order of Expos.	Order of Selections										Tot. P	Tot. F	Tot.																				
	1st		2d		3d		4th		5th					6th		7th		8th		9th		10th											
	P	F	T	P	F	T	P	F	T	P	F	T	P	F	T	P	F	T	P	F	T	P	F	T	P	F	T						
Rg	-	1	1	3	2	5	-	2	4	4	2	3	5	-	1	1	3	-	3	3	-	3	4	1	5	3	1	4	20	11	31		
Rt	-	1	1	-	1	1	2	3	5	7	2	9	2	-	3	3	-	3	3	-	3	3	-	-	-	-	-	3	21	11	32		
T	-	2	2	3	3	6	2	3	9	9	5	14	2	1	3	6	-	6	6	-	6	4	1	5	4	1	5	6	1	7	41	22	63
Rg	3	3	6	2	2	4	2	1	3	-	4	2	6	3	-	3	1	3	-	3	1	2	3	4	-	4	3	-	3	19	13	32	
Rt	6	3	9	3	3	6	3	2	5	1	3	4	3	-	3	2	1	3	-	2	2	-	2	-	-	-	-	1	22	9	31		
T	9	6	15	5	5	10	5	3	8	7	3	10	6	-	6	1	-	5	-	5	1	5	-	-	-	-	2	1	3	41	18	59	
Rg	-	-	-	1	-	1	3	6	9	3	6	6	-	2	2	1	3	-	3	1	2	3	4	-	4	3	-	3	19	13	32		
Rt	1	-	1	3	2	5	1	3	4	4	4	8	2	1	3	-	-	-	-	2	1	2	-	2	-	-	-	3	17	11	28		
T	1	-	1	4	2	6	4	9	13	7	7	14	2	3	5	1	2	3	-	3	3	2	5	5	-	5	6	-	6	36	24	60	
Rg	1	1	2	-	2	2	1	1	2	1	2	3	5	2	2	4	1	1	2	6	4	1	5	4	1	5	3	-	3	21	13	34	
Rt	1	2	3	3	1	4	1	2	3	1	1	2	1	5	6	5	1	6	1	5	-	5	-	5	2	-	2	1	21	12	33		
T	2	3	5	3	3	6	2	3	5	2	3	5	3	8	11	7	3	10	2	1	3	11	-	11	-	-	-	4	42	25	67		
Rg	19	5	24	-	1	1	-	2	2	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	20	11	31	
Rt	12	6	18	1	1	2	1	1	2	1	1	1	-	3	3	-	3	-	3	-	3	-	3	-	3	-	3	-	21	11	32		
T	31	11	42	1	2	3	1	1	2	1	4	5	-	3	3	-	3	-	3	-	3	-	3	-	3	-	3	1	41	22	63		
Rg	-	1	1	-	-	-	3	-	3	1	-	1	3	10	6	2	8	2	1	3	2	1	3	2	2	4	1	2	3	21	12	33	
Rt	1	-	1	-	-	-	1	-	1	2	1	3	5	2	7	2	7	2	4	6	4	1	5	4	1	5	2	5	7	20	13	33	
T	1	1	2	-	-	-	4	-	4	1	-	1	4	2	6	7	3	13	11	4	15	4	5	9	6	3	9	3	7	10	41	25	66
Rg	-	-	-	11	2	13	5	-	5	-	-	-	1	-	1	3	3	-	3	3	5	5	1	2	3	1	-	1	2	20	13	33	
Rt	-	1	1	7	1	8	4	-	4	4	-	4	2	-	2	3	9	12	1	-	1	-	1	-	-	-	-	1	22	12	34		
T	-	1	1	18	3	21	9	-	9	4	-	4	3	-	3	12	15	1	5	6	1	3	4	1	-	1	2	1	3	42	25	67	
Rg	-	-	-	-	1	1	2	1	3	5	-	5	-	-	7	2	7	2	3	5	2	1	3	2	1	3	2	1	3	6	21	12	33
Rt	-	-	-	3	-	3	-	-	-	2	-	-	-	-	-	4	8	12	4	2	6	1	1	2	4	2	6	1	2	16	11	27	
T	-	-	-	3	1	4	2	1	3	7	-	7	-	-	5	2	7	6	11	17	6	3	9	3	2	5	5	3	8	37	23	60	
Rg	-	-	-	-	-	-	-	2	5	3	2	5	3	-	3	1	4	1	4	5	1	4	5	3	2	3	1	4	5	19	13	32	
Rt	-	-	-	-	-	-	2	-	2	1	-	1	-	-	5	1	6	4	-	4	1	2	3	3	8	11	2	-	2	18	11	29	
T	-	-	-	-	-	-	2	-	2	4	2	6	3	-	3	10	13	7	1	8	2	4	6	4	12	16	5	2	7	37	24	61	
Rg	-	-	-	2	-	2	4	2	6	4	1	5	6	-	6	-	6	-	6	2	4	6	2	2	4	6	2	2	2	21	11	32	
Rt	-	-	-	-	-	-	3	-	3	6	-	6	3	-	3	-	3	-	3	1	4	3	4	3	1	4	3	5	8	21	11	32	
T	-	-	-	2	-	2	7	2	9	10	1	11	9	-	9	-	9	-	9	1	11	10	1	11	10	1	11	5	7	37	24	61	
Rg	23	11	44	19	10	29	20	11	31	19	12	32	20	13	33	20	12	32	21	12	33	20	12	33	20	12	32	19	12	31	201	118	319
Rt	22	13	35	20	9	29	18	11	29	21	11	32	21	13	34	21	11	32	20	12	32	17	11	28	17	11	28	18	10	28	198	112	310
Total	45	24	79	39	19	58	38	22	60	40	23	64	41	26	67	41	23	64	41	24	65	41	24	65	37	23	60	37	22	59	399	230	629

TABLE XXVIII (Continued)

*Distribution of Selections*

Computed from experiments with pictures (P) and figures (F) in which 10 cards are exposed in succession.

*Recognition (Rg) and Retention (Rt)*

*Subject: H-n*

Order of Expos.	Rg		Pictures Rt		T		Rg		Figures Rt		T		Total	
	pc	pc	pc	pc	pc	pc	pc	pc	pc	pc	pc	pc	pc	pc
1st	20	87	21	91	41	89	11	85	11	85	22	85	63	87
2d	19	83	22	96	41	89	9	69	9	69	18	69	59	79
3d	19	83	17	74	36	78	13	100	11	85	24	92	60	83
4th	21	91	21	91	42	91	13	100	12	92	25	96	67	93
5th	20	87	21	91	41	89	11	85	11	85	22	85	63	87
6th	21	91	20	87	41	89	12	92	13	100	25	96	66	92
7th	20	87	22	96	42	91	13	100	12	92	25	96	67	93
8th	21	91	16	70	37	80	12	92	11	85	23	90	60	83
9th	19	83	18	78	37	80	13	100	11	85	24	92	61	85
10th	21	91	20	87	41	89	11	85	11	85	22	85	63	87
Total	201		198		399		118		112		230		629	
Total pc.		87		86		87		91		86		88		87

Total Pictures exposed: Rg 230 — Rt 230 — total 460  
 Total Figures exposed: Rg 130 — Rt 130 — total 260  
 Total Cards exposed: Rg 360 — Rt 360 — total 720

Total Pictures selected: Rg 201 — Rt 198 — total 399  
 Total Figures selected: Rg 118 — Rt 112 — total 230  
 Total Cards selected: Rg 319 — Rt 310 — total 629



TABLE XXIX (Continued)

*Distribution of Selections*

Computed from experiments with pictures (P) and figures (F) in which 10 cards are exposed in succession.

Recognition (Rg) and Retention (Rt)

Subject: D-n

Order of Expos.	Rg		Pictures Rt		T		Rg		Figures Rt		T		Total	
	pc	pc	pc	pc	pc	pc	pc	pc	pc	pc	pc	pc	pc	pc
1st	15	83	15	83	30	83	7	54	8	62	15	58	45	71
2d	15	83	14	78	29	81	9	69	3	23	12	46	41	66
3d	14	78	15	83	29	81	9	69	9	69	18	69	47	76
4th	10	56	12	67	22	61	9	69	10	77	19	73	41	66
5th	12	67	16	89	28	78	8	62	10	77	18	69	46	74
6th	14	78	14	78	28	78	7	54	6	46	13	50	41	66
7th	12	67	10	56	22	61	9	69	7	54	16	62	38	61
8th	13	72	11	61	24	67	7	54	6	46	13	50	37	60
9th	16	89	12	67	28	78	5	38	6	46	11	42	39	63
10th	13	72	8	44	21	58	7	54	3	23	10	38	31	50
Total	134		127		261		77		68		145		406	
Total pc.		74		71		73		59		52		56		65

Total Pictures exposed: Rg 180 — Rt 180 — total 360  
 Total Figures exposed: Rg 130 — Rt 130 — total 260  
 Total Cards exposed: Rg 310 — Rt 310 — total 620

Total Pictures selected: Rg 134 — Rt 127 — total 261  
 Total Figures selected: Rg 77 — Rt 68 — total 146  
 Total Cards selected: Rg 211 — Rt 195 — total 406



of pictures and of figures. In delayed recognition this influence is not apparent. In immediate as well as in delayed recognition of pictures, and in immediate recognition of figures, the first item is least well remembered.

*E-n.* In immediate recognition of pictures the last card is most frequently selected, next the first and the second, and least frequently the fourth card. In delayed recognition of pictures the fourth and the fifth cards are most frequently selected, least frequently the first and the second cards. In immediate recognition of figures the last card is most frequently selected, next, the first, and least frequently the second card. In delayed recognition with figures the distribution of selections is more even, the second card being selected most, and the third least frequently. Hence, with this subject, recency and in less degree primacy have a favorable influence on selection in immediate recognition both of pictures and of figures. Recency has a favorable, and primacy an unfavorable influence on selection in delayed recognition of pictures; in delayed recognition of figures no such influence is evident.

*H-n.* Both in immediate and in delayed recognition of pictures as well as of figures the selections are fairly evenly distributed over the various items in the set, and there is therefore no marked influence of primacy and recency with this subject.

*D-n.* In delayed recognition of both materials the last card is selected with decreased frequency. In immediate recognition this is less apparent. In the added results for immediate and for delayed recognition of pictures the first card in order of presentation is most frequently, and the last card least frequently selected. In the added results for immediate and for delayed recognition of figures the last card is least frequently selected. It would seem, then, that with this subject recency has a slightly unfavorable influence on selection, more marked in delayed than in immediate recognition. The added results for pictures may indicate that primacy has a slightly favorable influence on selection.

## VI. COMPARISONS AND CONCLUSIONS

### I. APPREHENSION

There is a general difference in apprehension between the various subjects which will be dealt with under the subsequent sub-heading.

Both stimulation time and the character of the material affect apprehension in the defective subjects.

Table XXX<sup>1</sup> and Figure 11 show the relation between the aver-

TABLE XXX  
*Experiments with Pictures and Variation in Time of Exposure*  
Immediate Recognition

	Time of Exposure (per cent score)					Total Decline	
	1"	1/5"	1/10"	1/25"	1/50"	Absolute (per cent score)	Relative (per cent)
"Normal"	96	95	89	63	49	47	49
H-n	95	100	93	90	87	13	13
D-n	68	63	57	30	15	53	78
McG	73	54	53	20	6	67	92
E-n	32	37	35	—	—	37	100

age scores for normal subjects and the scores for the defective subjects in immediate recognition of pictures. Comparing these scores we find that H-n has the highest general average as well as the greatest stability<sup>2</sup> which also is greater than in any of the individual normal scores. The scores of D-n are inferior to the normal both in general average and in stability, and similarly those of McG which are inferior also to those of D-n. E-n has the lowest scores; the small difference between his three scores indicates that his apprehension is poor regardless of the stimulation time.

Table XXI and Figure 12 show the relation between the average scores for normal subjects and the scores for the defective subjects in immediate recognition of figures. The scores of H-n are superior to the average normal both as regards general aver-

<sup>1</sup> The "relative decline" in tables XXX-XXXVII is measured in percentage of the highest score.

<sup>2</sup> We measure stability in terms of relative decline.

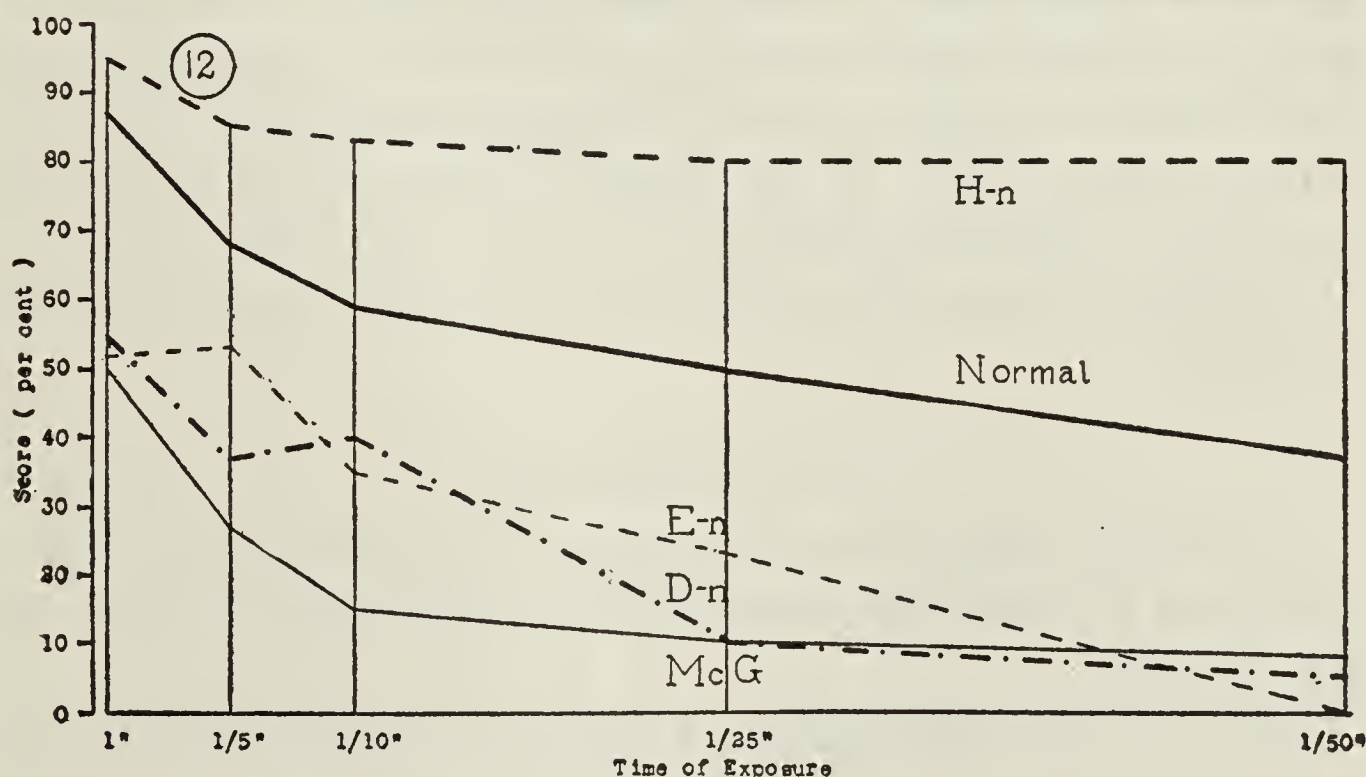
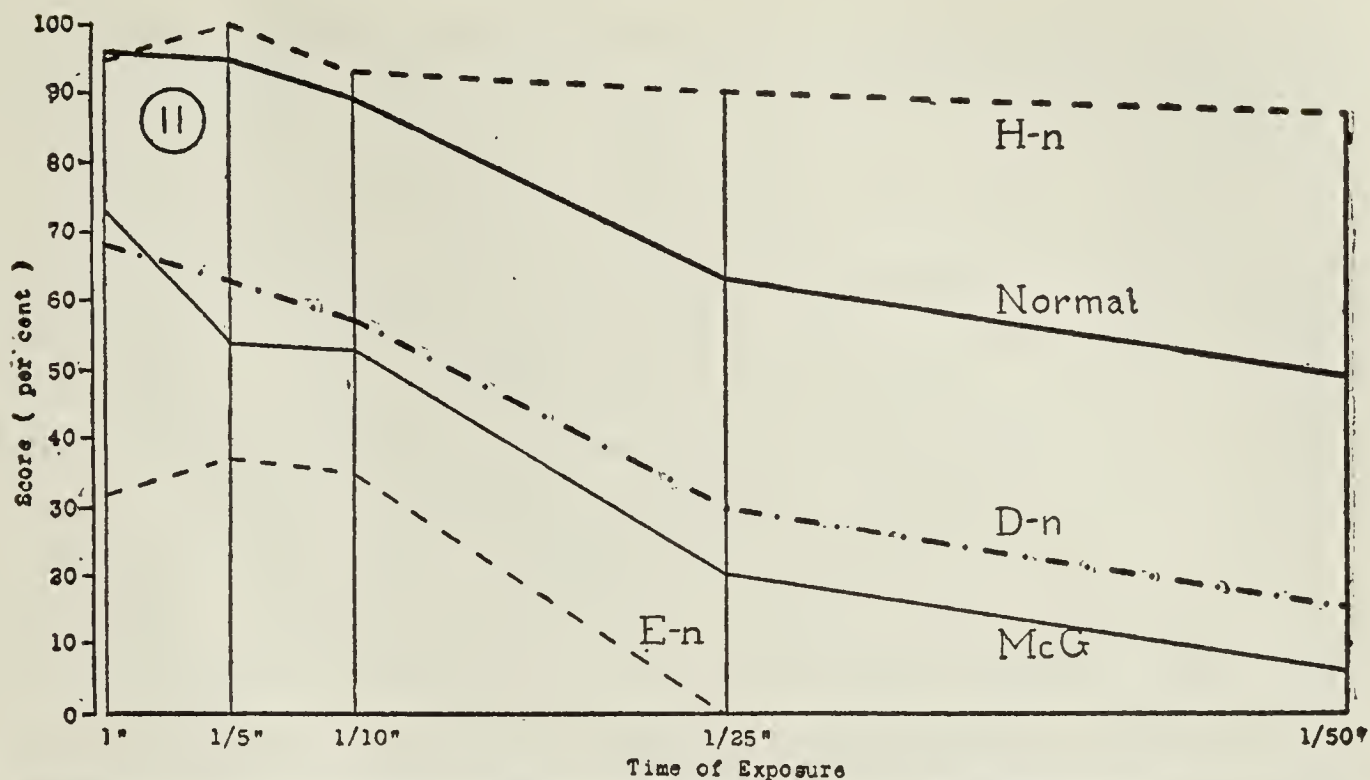


FIG. 11.—Pictures. Variation in Time of Exposure. Per cent score.

FIG. 12.—Figures. Variation in Time of Exposure. Per cent score.

Both figures show the average results for the normal subjects and the individual results for the defective subjects.

TABLE XXXI

Experiments with Figures and Variation in Time of Exposure  
Immediate Recognition

	Time of Exposure (per cent score)					Total Decline	
	1"	1/5"	1/10"	1/25"	1/50"	Absolute (per cent score)	Relative (per cent)
"Normal"	87	68	59	50	37	50	58
H-n	95	85	83	80	80	15	16
D-n	55	37	40	10	5	50	91
McG	50	27	15	10	8	42	84
E-n	52	53	35	23	—	53	100

age and stability, moreover, they show greater stability than any individual normal series of scores (*cf.* Table II). The scores of D-n are inferior to the normal both as regards general average and stability. The scores of McG are further inferior to the normal in general average, although they show somewhat greater stability than those of D-n. The general average for E-n is slightly superior to that for D-n but inferior to the normal. If, however, we compare his first four scores with those of D-n and of McG, we find a greater stability in the scores of E-n.

Thus it may be concluded that pictures offer greater facility for apprehension than figures with normal subjects and with H-n, D-n, and McG, but in the case of E-n the reverse is true. Apprehension declines with a gradual reduction in the time of exposure, more rapidly with figures than with pictures in most cases, but more rapidly with pictures than with figures in the case of McG. The least decline is shown by H-n, both with pictures and with figures; the other defective subjects show greater relative decline than is found in the average normal results with both materials. E-n shows the greatest decline with both materials. D-n shows the next greatest decline with figures, and McG with pictures.

## 2. SPAN OF MEMORY

Under this sub-heading we shall deal with the results in experiments for immediate recognition and with variation in number of cards.

Table XXXII and Figure 13 show the relation between the

	Number of Cards (per cent score)					Total Decline	
	3	5	7	9	(—)	Absolute (per cent score)	Relative (per cent)
"Normal"	100	100	94	91	(87)	9	9
H-n	100	100	100	90	(—)	10	10
D-n	60	63	63	60	(—)	3	5
McG	67	68	52	44	(—)	24	35
E-n	33	46	33	33	(—)	13	28

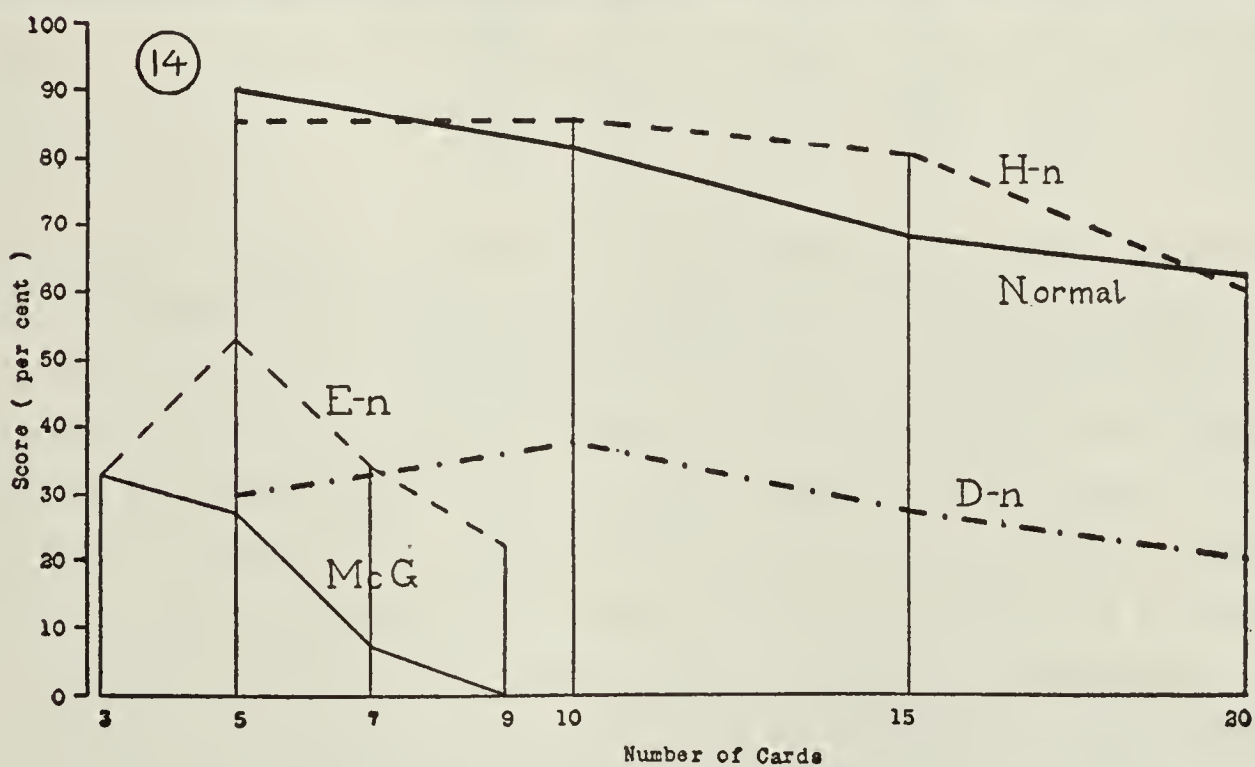
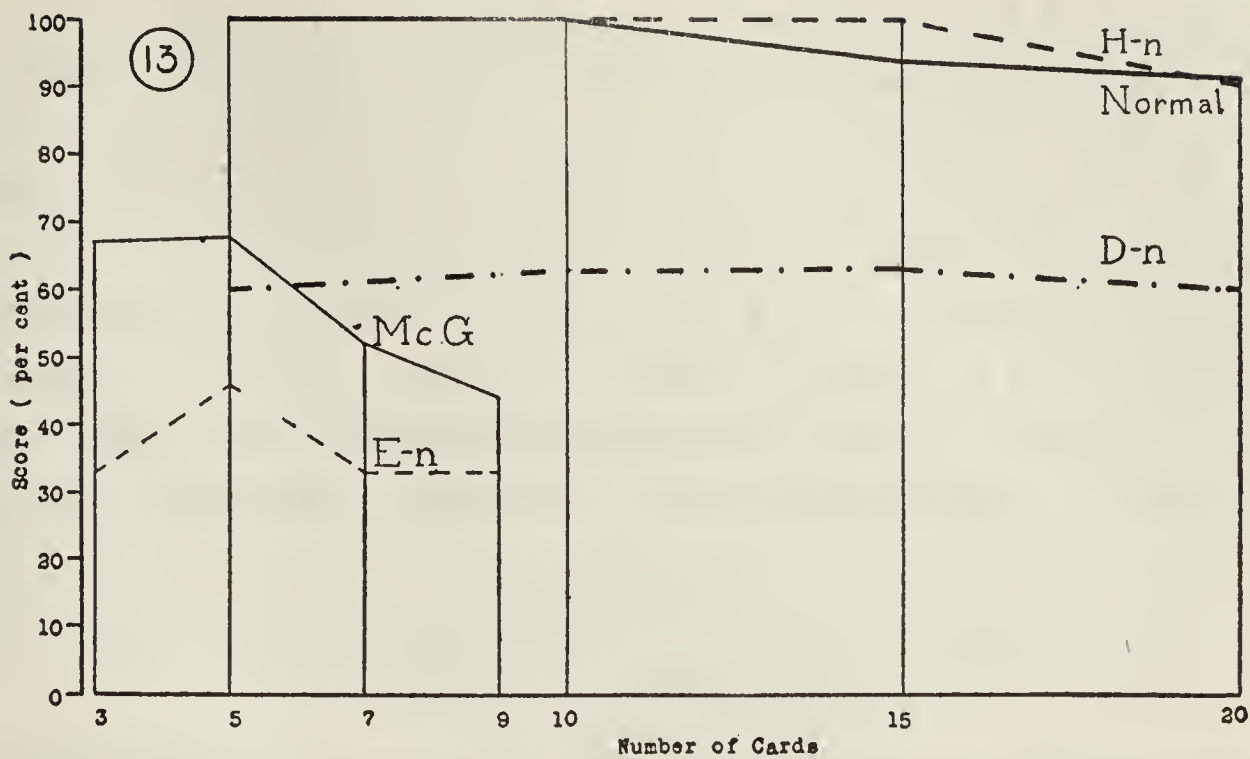


FIG. 13.—Pictures. Variation in Number of Cards. Per cent score.

FIG. 14.—Figures. Variation in Number of Cards. Per cent score.

Both figures show the average results for the normal subjects and the individual results for the defective subjects.

average scores for normal subjects and the scores for the defective in experiments with pictures. In each series of scores the highest results are reached with the "normal" set of cards. The results of H-n are on a par with the average normal results, those of McG and of D-n are considerably, and those of E-n greatly, below the normal. With an increased number of cards to the set

the score of H-n declines more sharply than the normal score. The average decline in his score is slightly greater than that in the normal. The decline in the score of D-n is much smaller than that in the normal, giving the impression that within the limits of the experiment she is able to recognize a more or less constant proportion of items. The score of McG shows the greatest absolute as well as relative decline. The score of E-n is constant with exception for the relatively high figure for the "normal" set.

Table XXXIII and Figure 14 show the relation between the

TABLE XXXIII  
*Experiments with Figures and Variation in Number of Cards*  
Immediate Recognition

	Number of Cards (per cent score)					Total Decline	
	3	5	7	9	(—)	Absolute (per cent score)	Relative (per cent)
"Normal"	90	81	68	62	(56)	28	31
H-n	85	85	80	60	(—)	25	29
D-n	30	37	27	20	(—)	17	57
McG	33	27	7	0	(—)	33	100
E-n	33	53	34	22	(—)	31	58

average scores for normal subjects and the scores for the defective in experiments with figures. In general average the scores of H-n are on a par with the normal, those of E-n are considerably lower, those of D-n are next, and those of McG the lowest. The scores of H-n show slightly less decline than the normal, those of McG show the greatest decline. The least absolute decline is found for D-n, the relative decline for whom, however, is considerably in excess of the normal. For E-n the relative decline is about the same as for D-n.

Comparing these results with those obtained in experiments with pictures (Table XXXII) we find that with all but one subject the former are much inferior to the latter. With E-n the average "figure" score is but slightly inferior to the average "picture" score, but this inferiority arises from the results with 9-card sets. For 3-card sets the results are the same with both materials, and the "figure" score is superior to the "picture" score with 5- and 7-card sets. The various scores show a considerably greater total decline in experiments with figures than in experiments with pictures.

In the defective subjects the span of memory is thus decidedly greater for pictures than for figures in all but one case in which with a limited number of items the opposite is true.

In his experiments on normal subjects with advertisements for visual stimulation Strong found a steady decrease in the proportion of advertisements that could be recognized as the series increased.<sup>3</sup> This is found both with pictures and with figures in our experiments with normal subjects. What has been said in the foregoing indicates a more irregular influence of this factor in experiments with defective subjects, and especially with those whose memory defect is considerable.

### 3. RETENTION

The differences between the scores for delayed and for immediate recognition in experiments with pictures and variation in time of exposure with normal and with defective subjects are shown in Table XXXIV. H-n shows less difference than is found

TABLE XXXIV  
*Experiments with Figures and Variation in Time of Exposure*

	Differences between Delayed and Immediate Recognition					Average Difference	
	Time of Exposure					Absolute	Relative
	(per cent score)						
	1"	1/5"	1/10"	1/25"	1/50"		
"Normal"	1	2	3	2	9	3.4	4.3
H-n	0	0	0	0	7	1.4	1.5
D-n	8	6	4	10	10	7.6	16.3
M-G	13	21	20	0	-1	10.6	25.7
E-n	1	10	19	—	—	6.0	28.8

for the average normal. It should be remembered, however, that with the normal subjects the retention time was increased from 3 to 5 minutes. E-n has the greatest average relative difference, with McG a close second. The average difference for D-n is considerably in excess of that for the normal. The difference for the normal and for H-n shows a tendency to increase with decreasing stimulation time. This tendency is clearly marked for E-n with exposures of 1", 1/5", and 1/10", less clearly for D-n.

Table XXXV shows the differences between the scores for de-

<sup>3</sup> *The Effect of Length of Series upon Recognition Memory*, by Edward K. Strong, Jr. *Psychol. Rev.*, 1912, XIX, pp. 447 et seq.

TABLE XXXV  
*Experiments with Pictures and Variation in Number of Cards*  
 Differences between Delayed and Immediate Recognition

	Number of Cards (per cent score)					Average Difference	
	3	5	7	9	(—)	Absolute (per cent score)	Relative (per cent)
"Normal"	0	2	4	10	(16)	4.0	4.2
H-n	0	0	17	10	(—)	6.8	6.9
D-n	0	6	36	32	(—)	18.5	30.1
McG	34	32	28	36	(—)	32.5	56.5
E-n	33	18	28	33	(—)	28.0	77.2

layed and for immediate recognition in experiments with pictures and variation in number of cards. The average difference for H-n is slightly greater than the average normal, but not in excess of that for C-h among the normal subjects. For the other defective subjects the average difference is far in excess of the average normal. A tendency of the difference to increase with an increasing number of cards is more clearly marked in the normal than in the other results. With H-n and D-n the difference is greatest for the 15-card set, it decreases for the 20-card set. With the remaining subjects it is more irregularly distributed, with a high figure for the 3-card set.

Table XXXVI shows the differences between the scores for

TABLE XXXVI  
*Experiments with Figures and Variation in Time of Exposure*  
 Differences between Delayed and Immediate Recognition

	Time of Exposure (per cent score)					Average Difference	
	1"	1/5"	1/10"	1/25"	1/50"	(per cent score)	(per cent)
"Normal"	10	6	6	10	10	8.4	14.0
H-n	15	8	8	5	10	9.9	10.9
D-n	17	17	19	10	35	19.6	66.7
McG	10	14	5	0	28	11.4	51.8
E-n	22	21	20	16	—	15.8	48.5

delayed and for immediate recognition in experiments with figures and variation in time of exposure. The average relative difference for H-n is smaller than that for the average normal, that for E-n is greatly in excess of the normal and that for McG slightly greater than that for E-n. D-n has the greatest average relative difference. The differences are unevenly distributed over the various exposures, with a tendency to increase with the long-



est and the shortest exposures. The difference for E-n decreases when the time of exposure is reduced.

Table XXXVII shows the differences between the scores for

TABLE XXXVII  
*Experiments with Figures and Variation in Number of Cards*  
Differences between Delayed and Immediate Recognition

	Number of Cards (per cent score)					Average Difference	
	3	5	7	9	(—)	Absolute (per cent score)	Relative (per cent)
"Normal"	5	10	15	20	(25)	5.8	7.6
H-n	6	7	4	6	(4)	7.8	10.0
D-n	10	8	3	10	(—)	18.5	64.9
McG	10	17	27	20	(—)	7.0	41.8
E-n	0	14	14	0	(—)	7.8	21.8
	0	21	5	5	(—)		

delayed and for immediate recognition in experiments with figures and variation in number of cards. The average difference for H-n is greater than the average normal, the average relative difference for E-n is about twice that for H-n, that for McG about twice, and that for D-n about three times that for E-n. The distribution of the differences over the various sets of cards is irregular. In the case of McG it is confined to the two middle sets, in that of E-n it is concentrated on the normal set.

We reach the following conclusions: the retention interval reduces the results for recognition both with normal and with defective subjects; with normal subjects this reduction is greater with figures than with pictures; with pictures it increases with the number in the series, with figures no such increase is apparent; with pictures it also increases with a reduction in time of exposure; with figures there is less difference for exposures of 1/5" and 1/10" than for longer and for shorter exposures.

With H-n the influence of the retention interval in experiments with pictures is less marked than in the average normal results when the "normal" set is used. In experiments with figures the sum of the differences for the 10-card and the 15-card sets is the same with H-n as in the average normal results. In experiments with pictures as well as with figures the sum of the differences for the 15-card and the 20-card sets is greater with H-n than in the average normal results. Reduction in time of exposure has

less detrimental effect on retention with H-n than with the average normal in experiments with pictures, and about the same effect with both in experiments with figures. Thus the power of retention of H-n is not inferior to the average normal with smaller sets of cards, but an increase of the number in the series has a more detrimental effect on the power of retention of H-n than on that of the average normal.

With the remaining subjects the retention interval reduces the results in recognition in various degrees, both with pictures and with figures.

*D-n.* The respective relations between her average relative differences and those in the normal results are:

Pictures	and	variation	in	time	of	exp.	.264
"	"	"	"	"	no.	of	cards .140
Figures	"	"	"	time	of	exp.	.210
"	"	"	"	"	no.	of	cards .117

The influence of the retention time factor is relatively greater with figures than with pictures, and there is a further reduction with an increase of the number in the series.

*McG.* The respective relations between his average relative differences and those in the normal results are:

Pictures	and	variation	in	time	of	exp.	.167
"	"	"	"	"	no.	of	cards .074
Figures	"	"	"	time	of	exp.	.270
"	"	"	"	"	no.	of	cards .182

The influence of the retention time factor is relatively greater with pictures than with figures. With pictures there is a further decrease when there is a shortening in the time of exposure; with figures the opposite tendency obtains. There is little change in this influence consequent upon an increase of the number in the series with pictures; with figures no influence is noticeable with series of 3 and 9 cards.

*E-n.* The respective relations between his average relative differences and those in the normal results are:

Pictures	and	variation	in	time	of	exp.	.150
"	"	"	"	"	no.	of	cards .054
Figures	"	"	"	time	of	exp.	.289
"	"	"	"	"	no.	of	cards .349

The influence of the retention time factor is relatively greater

with pictures than with figures. With pictures it increases, with figures it decreases when the time of exposure is reduced. With pictures it increases with an increase of the number in the series; with figures it is greater in series of 5 cards than in longer series, and it is absent in series of 3 cards.

Differences in purpose and method exclude a direct comparison between the results obtained by Moore and those of the present investigation.<sup>4</sup>

#### 4. RECOGNITION AND RECALL

The relative differences between recognition and recall in the average scores for normal subjects in experiments with five variations in time of exposure may be expressed as follows, counting from 1" to 1/50" exposure: 11, 15, 15, —10, —14 per cent.<sup>5</sup> In other words, the recognition scores are superior to the recall scores for 1" to 1/10" exposures, and the reverse is true for shorter exposures. This relation does not obtain in all the individual scores. With all the normal subjects, however, the recognition scores are superior to the recall scores for 1" and 1/5" exposures (see Table I). In experiments with variation in number of cards the corresponding relative differences for the average normal scores are, counting from sets of 5 to sets of 20 (25) cards: 0, 6, 9, 21, (24 per cent). Hence, the results in recall become increasingly inferior to those in recognition as the number in the series increases.

The average normal recall scores and the recall scores for the defective subjects are shown in Figures 15 and 16.

*H-n.* While H-n has very high recognition scores his recall scores are considerably below the average normal recall scores, and also inferior to any of the individual normal recall scores. His recall score remains constant for exposures from 1" to 1/25" and declines for exposure of 1/50". The following relative differences between recognition and recall appear in experi-

<sup>4</sup> *Op. cit.*

<sup>5</sup> These figures express the difference between the two scores in percentage of the highest. The positive values indicate that the recognition score is highest, negative that the recall score is highest.

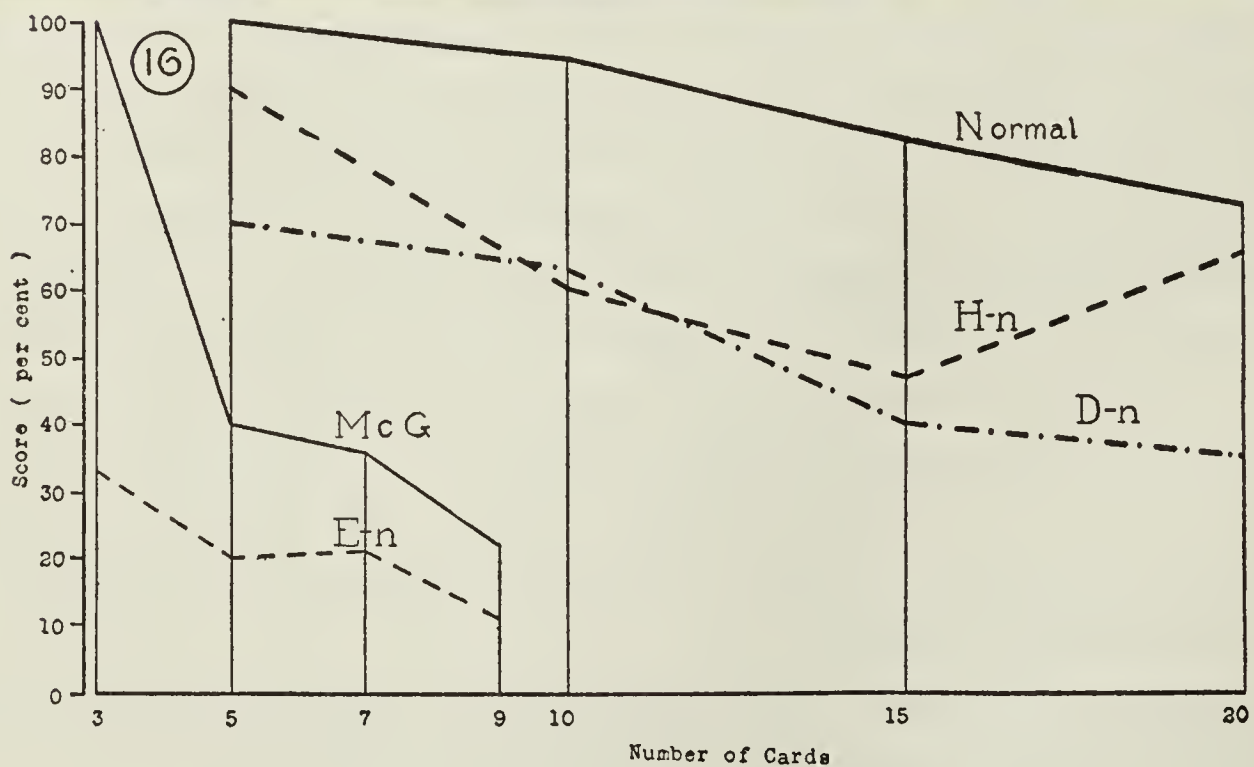
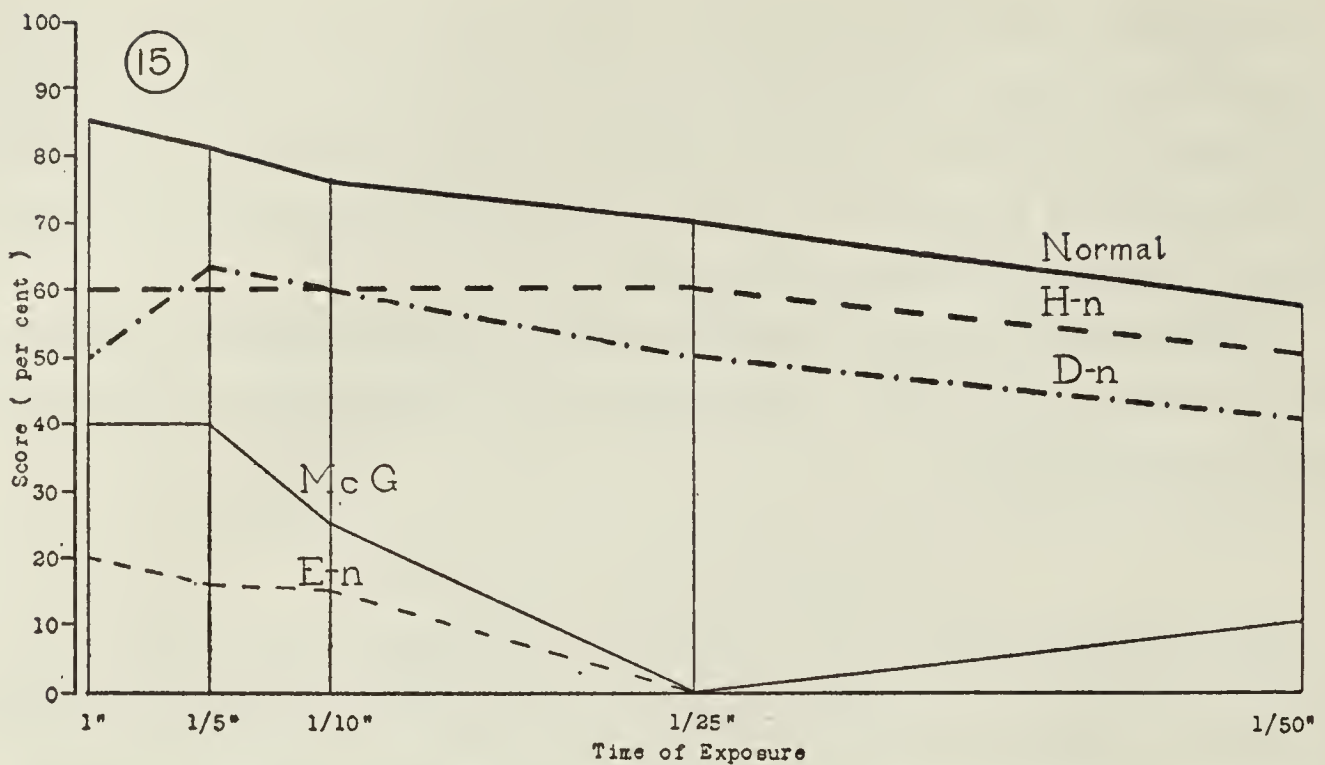


FIG. 15.—Variation in Time of Exposure. Per cent scores.

FIG. 16.—Variation in Number of Cards. Per cent scores.

Both figures show the average results for normal subjects and the results for the defective subjects in Recall.

ments with variation in time of exposure: 37, 40, 35, 33, and 43 per cent. In experiments with variation in number of cards the corresponding differences are, counted from sets of 5 to sets of 20 cards: 10, 40, 53, and 28 per cent. His recall memory is therefore inferior to the normal; it is not greatly affected by a reduction in time of exposure, but the proportion of items re-

called decreases rapidly with an increase of the number in the series.

*D-n.* In experiments with variation in time of exposure the relative differences between the scores for recognition and for recall are 26, 0, -5, -40, and -63 per cent, respectively. In experiments with variation in number of cards they are, respectively: -14, 0, 21, and 42 per cent. Her recall scores are considerably lower than the average normal, but they show little decline when the time of exposure is reduced. The relation between her recall and her recognition scores is, generally speaking, similar to that for the average normal, with the exception that in her case the differences for both the longest and the shortest exposures are greater than in the case of the average normal. Her recall memory is superior to the recognition memory for sets of 5 cards, equal to the recognition memory for sets of 10 cards, and inferior for larger sets. This inferiority increases at a proportionately higher rate than with normal subjects as the number in the series is increased.

*McG.* In experiments with variation in time of exposure the relative differences between the scores for recognition and for recall are, respectively: 45, 26, 53, 100, and -40 per cent. In experiments with variation in number of cards they are for sets of 3, 5, 7, and 9 cards, respectively: -33, 41, 31, and 50 per cent. His recall scores fall greatly below the average normal and decrease both with a reduction in the time of exposure and with an increase in the number in the series. In their relation to the recognition scores they are proportionately inferior to the normal recall scores, except for the 3-card set for which the score is perfect.

*E-n.* In experiments with variation in time of exposure the relative differences between the scores for recognition and for recall are 35, 57, and 57 per cent, respectively. In experiments with variation in number of cards they are, respectively: 0, 57, 36, and 67 per cent. His recall scores are very low, declining both with a reduction in the time of exposure and with an increase in the number in the series. With exception of that for the 3-

card set they are inferior to the normal in their relation to the recognition scores.

Dr. Achilles experimented with subjects afflicted with the Korsakow psychosis, general paralysis, brain syphilis, and arterio-sclerosis, using four kinds of material, viz., words, forms, proverbs, and syllables, which were presented in separate series of 25 items, each presentation lasting 50 seconds. Experiments were made both for recognition and for recall. In addition, a series of 6 pictures was presented for recognition only. The experimenter remarks that "the data of all the cases are not comparable, for the conditions of the experiment were not the same for each patient. Some of the patients were unable to see well, and for them it was necessary to . . . present the material auditorily. When it was possible . . . the materials were . . . presented visually." She concludes that "all show a memory defect and the defect is present in both recall and recognition," and that "one finds the scores among the Korsakoffs lower than those among the general paralysis and arterio-sclerosis cases. There is no striking difference between the way the diseases affect the recall and recognition."<sup>6</sup> The tabulated results<sup>7</sup> show that the relation between recall and recognition varies greatly with different subjects, and with different materials for the same subject.

##### 5. PRIMACY AND REGENCY

Table XXXVIII shows the distribution of selections with the "normal" set of cards for the four defective subjects. It is compiled from Tables XXVI-XXIX. Tables XXVIII and XXIX have been reduced by combining the figures for the first and second, third and fourth items exposed, etc., and similarly the figures for the first and second, third and fourth selections, etc.

On an average, the last and the next last items exposed are most frequently, and the third item least frequently selected in immediate recognition of pictures; with figures the last item is

<sup>6</sup> *Op. cit.*, p. 64.

<sup>7</sup> *Ibid.*, p. 65.

TABLE XXXVIII  
Summary of Distribution of Selections

Figures give per cent selections of total number exposed

1. Pictures

Order of Exposure	Subjects								Average	
	Mc-G		E-n		H-n		D-n		Rg	Rt
	Rg	Rt	Rg	Rt	Rg	Rt	Rg	Rt	Rg	Rt
1st (1st & 2d)	53	53	63	43	85	93	83	81	71	68
2d (3d & 4th)	67	63	63	43	87	82	67	75	71	66
3d (5th & 6th)	57	70	60	50	89	89	72	83	70	73
4th (7th & 8th)	83	63	53	53	89	82	69	58	74	64
5th (9th & 10th)	87	67	80	53	87	82	81	56	85	65
Average	69	63	64	48	88	86	74	71	74	67
Av. diff. Rg & Rt	6		15		2		3		7	
Diff. from Av.	-5	-4	-10	-19	+14	+19	±0	+4		

2. Figures

Order of Exposure	Subjects								Average	
	Mc-G		E-n		H-n		D-n		Rg	Rt
	Rg	Rt	Rg	Rt	Rg	Rt	Rg	Rt	Rg	Rt
1st (1st & 2d)	38	58	73	58	77	77	62	42	63	59
2d (3d & 4th)	54	54	58	62	100	88	69	73	70	69
3d (5th & 6th)	73	54	62	54	88	92	58	62	70	66
4th (7th & 8th)	46	58	62	58	96	88	62	50	67	64
5th (9th & 10th)	92	54	85	58	92	85	46	35	79	58
Average	61	56	68	58	91	86	60	53	70	63
Av. diff. Rg & Rt	5		10		5		7		7	
Diff. from Av.	-9	-7	-2	-5	+21	+23	-10	-10		

most frequently, and the first item least frequently selected in immediate recognition. In delayed recognition the third item is most frequently, and the fourth item least frequently selected with pictures; with figures the second item is most frequently, and the last item least frequently selected. Thus recency has a marked effect on immediate recognition with both materials. Individual results have already been described in Section V.

## 6. CONCLUSIONS

I. Although the defective subjects who were tested showed a memory defect which appeared essentially the same when clinically considered, the experiments show that the memory defect varies in these subjects. The amnesia in the subjects under investigation is due both to faulty apprehension and to faulty retention. Both recognition and recall are affected. The defect is

present with pictures, which may be described in verbal terms, and also with figures, in which a verbal description is impossible (or at least improbable). The memory for pictures is usually better than that for figures.

2. Apprehension and retention abilities are affected to varying degrees in the four subjects. The recall memory is also seriously affected. One subject showed an impairment in recognition only for a great number of items to be remembered simultaneously. Although the memory for pictures (visual-kinaesthetic-auditory) is usually better than that for figures (purely (?) visual), in one case the reverse was found.

3. The defective subjects investigated showed, in general, the same effects as normal subjects in apprehension and memory following brief or longer exposures, and the beneficial effects of primacy, recency, and repetition.



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